

# ORBITER TILE IMPACT TESTING

Final Report

*for*

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*Prepared for*

NASA  
Johnson Space Center  
Houston, Texas

*Prepared by*  
Drew L. Goodlin

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## **1.0 INTRODUCTION**

This final report presents the results of a study in which Space Shuttle Orbiter high temperature reusable surface insulation (HRSI) tiles were impacted with NCFI (North Carolina Foam Insulation) 24-124 foam insulation. The objectives of the study were to: (1) evaluate the tile damage capability of NCFI 24-124 foam fired at various angles of attack, velocities and sizes; (2) confirm the current data base established from previous tile impact tests, and (3) to obtain high speed photographic records of the foam impact. Background information on this subject is discussed in the following section. A discussion of the test equipment, test matrix and procedures is given in Section 3.0. Tabulated test results are presented in Section 4.0 with further discussions given in Section 5.0.

## **2.0 BACKGROUND**

Originally the external tank on the orbiter was coated with a sprayed on foam insulation material known as SOFI. Due to environmental concerns, the SOFI material was replaced with NCFI 24-124 foam insulation. The first orbiter flight to have the NCFI 24-124 foam insulation was Flight STS-87. During this flight, the external tank of the Orbiter experienced a significant loss of thermal protection material from the intertank thrust panel region. This problem did not occur with the previously used SOFI insulation material. The NCFI 24-124 foam materials lost from the thrust panels have been implicated as causing significant damage to the HRSI tiles on the lower surface of the Orbiter. Subsequent modifications to the intertank thermal protection material for future STS Flights -89, 90 and 91 did show improvements; however, these improvements did not eliminate the problem. This project was conducted to characterize the damage inflicted on HRSI tiles by the NCFI 24-124 foam insulation material and to provide information to NASA that could be used to correlate to observed flight damage.

### **3.0 EXPERIMENTAL SETUP AND TEST PROCEDURES**

The following section describes the equipment used to conduct the impact tests, the Orbiter HRSI tile targets, the NCFI 24-124 foam projectiles, test procedures, and the test matrix.

#### **3.1 Test Facility and Equipment Description**

All testing was completed at Southwest Research Institute's Ballistics and Explosive Range located in San Antonio, Texas.

##### **3.1.1 Compressed Gas Gun**

The small compressed gas gun (Figure No. 1) was used to launch the foam projectiles at the Orbiter HRSI tile targets. High pressure helium gas was chosen as the driver gas to propel the foam projectiles to the desired velocities. Originally it was thought that the various sizes of foam could best be launched using a sabot package. However, early on in the program, it became apparent that the only feasible way to launch the fragile foam projectiles without breaking them up was to build custom barrels that had a bore dimension which matched the cross section of each projectile size. Three barrels were fabricated including a 1.0" x 1.0" square bore barrel for the 1.0" x 1.0" x 1.0" and 1.0" x 1.0" x 3.0" projectiles, a 3/8" diameter barrel for the 3/8" dia. x 1.0" and 3.0" long projectiles, and a 0.89" x 0.25" rectangular barrel for the 0.89" x 0.89" x 0.25" projectile. The 1.0" x 1.0" and the 0.89" x 0.25" square barrels were 11 feet long. The 3/8" barrel was 8 feet long. All three barrels were fabricated with a flange that mated to the pressure chamber of the small gas gun.

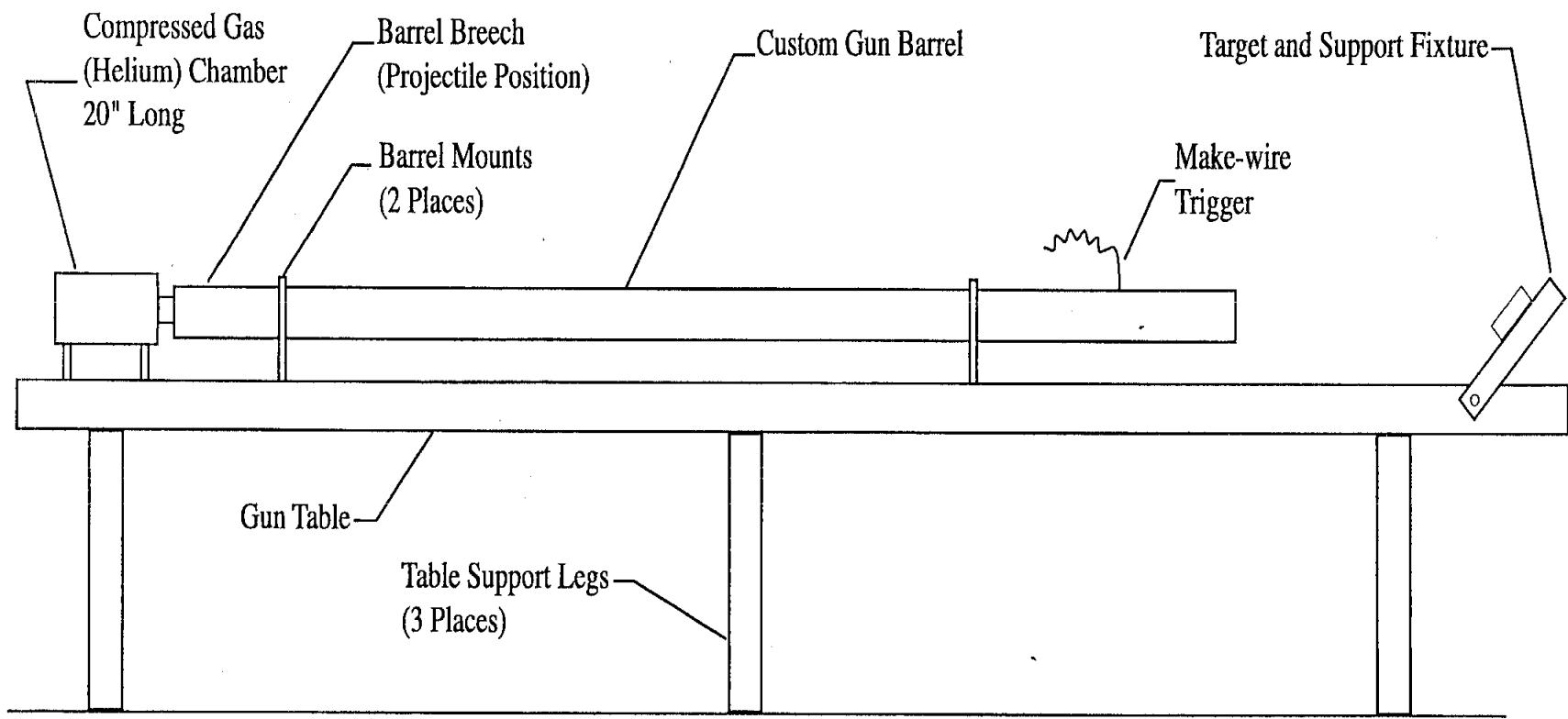
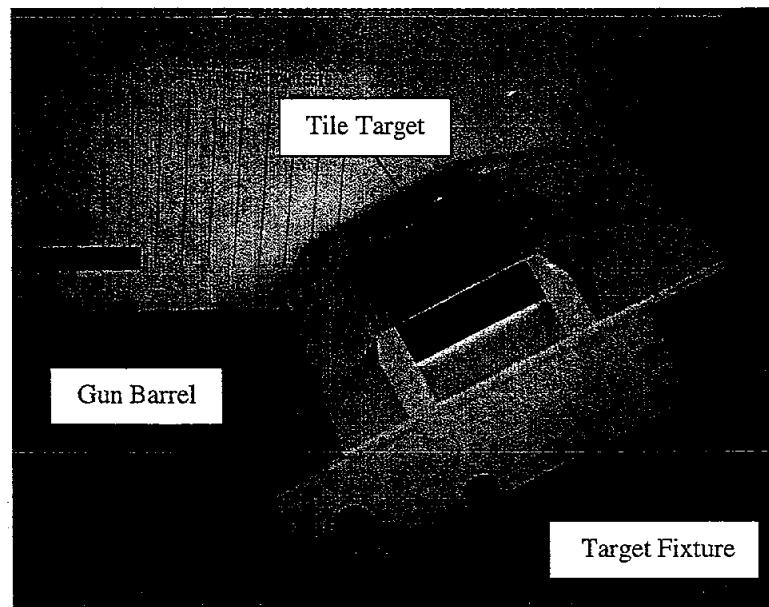


Figure 1: Compressed Gas Gun

### **3.1.2 Target Fixture**

A rigid target fixture (Figure No. 2) was fabricated from  $\frac{1}{4}$ " thick steel plate. The target fixture was clamped rigidly to the gun support structure. The tile targets were fastened to the target fixture using fiber-reinforced tape as requested by the sponsor. The target fixture was easily rotated to acquire the necessary impact incidence angle.



**Figure No. 2: Rigid Target Fixture**

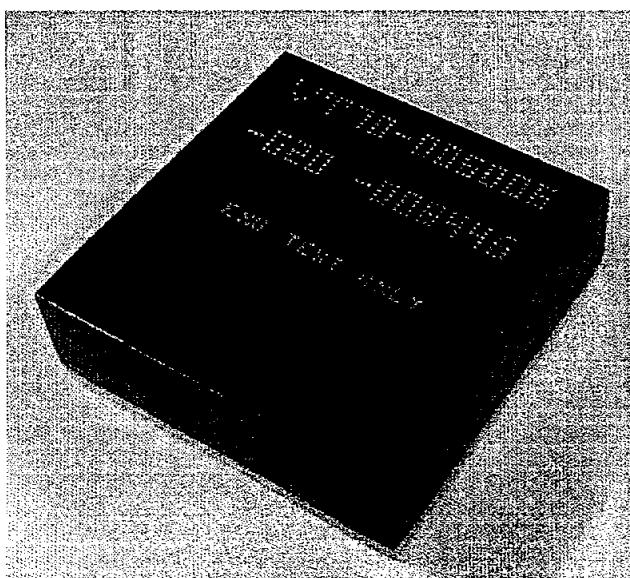
### **3.1.3 Ultra High Speed Digital Imaging**

To film the high velocity projectile impacts on the Orbiter HRSI tiles, the Imacon 468 Ultra High Speed Digital imaging system was used. The Imacon 468 employs high-resolution charge couple device (CCD) sensors coupled to a micro channel plate intensifier to acquire short duration exposures of high-speed events. This system provides eight (8) separate images of the event and can have exposure times as short as 10 ns, which is equivalent to a frame rate of 100 million frames-per-second. Test images are immediately available for review after each test. Filming the impacts provided information about the integrity and orientation of the projectile before,

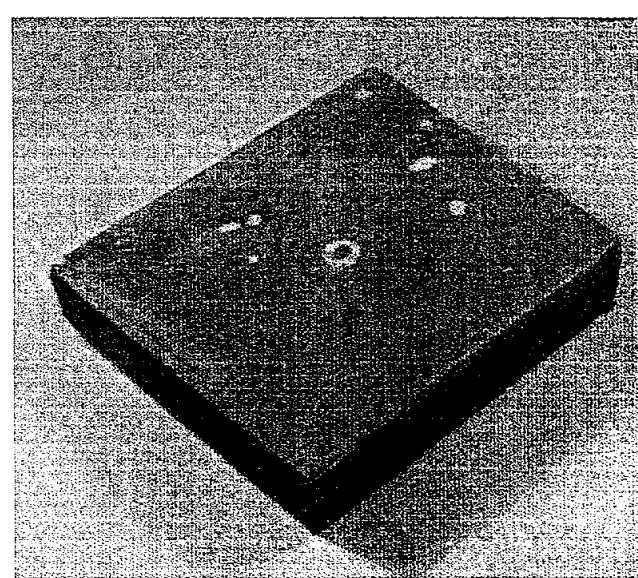
position of the selected feature, the velocity of the object along the calibrated shot line is calculated.

### 3.2 Tile Target

A total of 18 engineering tiles and 37 used flight tiles, shown in Figure No. 4, were tested in this study. The tiles were LI-900 HRSI (9 pounds per cubic inch) as flown on the underside of the Orbiter. A mixture of both engineering and flight tiles were tested under similar conditions to evaluate the conditions of aging on the impact behavior and failure mechanisms. Most of the tiles tested measured 6" x 6" x 2". A select few were slightly thinner with a thickness of approximately 1.5". The tiles were impacted on the exterior or 6" x 6" coated face. Typically, each tile was used for two tests, one impact on each half of the tile face provided that damage did not interfere with the other test. If the tile was not damaged in a test it was reused in the next test. Pretest tile damage such as cracking, voids, and repaired areas was recorded on the data record sheets. Pretest damage areas were avoided, when possible, by carefully selecting the impact location on the tile.



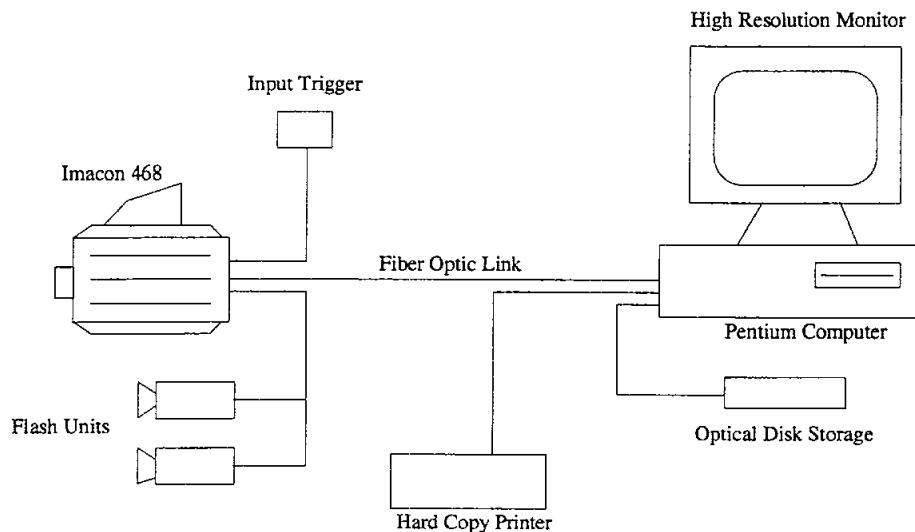
(A) Engineering Tile



(B) Flight Tile

Figure No. 4

during, and after impact. The tile targets response to the impact can also be monitored. Triggering of the camera was accomplished using a high voltage make circuit system mounted at the end of the barrels. As the projectile reaches the end of the gun barrel, a tiny braided wire is pushed up against the inside of the barrel. This completes the circuit, which triggers the camera. The tiny make-wire left a very shallow groove in the projectiles but did not interfere with the flight of the projectile. The digital images were also used to measure the projectile velocity (described in Section 3.1.4). Figure No. 3 is a diagram showing the camera system layout.



**Figure No. 3: Ultra High Speed Imacon 468 Digital Camera System**

### 3.1.4 Velocity Measurement

Projectile velocity was measured using the built-in features of the Imacon 468 Ultra High Speed Digital Imaging System. A part of the camera pretest setup procedure includes performing a dimensional calibration of the shot line in the field of view. After recording a test, the Imacon analysis software allows the user to select, with a crosshair cursor, the location of a unique feature of the projectile (i.e. the leading edge). This unique feature is selected in any two of the eight images. Since the delay time of the image is automatically recorded, as is the change in

### **3.3 Foam Projectiles**

All foam projectiles were NCFI 24-124 samples machined from production sprays performed per requirements below:

- Booth Temperature      103°F±2°F
- Booth Humidity    10%±2%
- Substrate Temperature    125°F±5°F
- Output 25.6 lbs/min/gun
- Hoist Velocity    14.46 inch/min
- RPM/Gun Angle/Clocking/Other parameters standard I/T (with NDS/TPV)

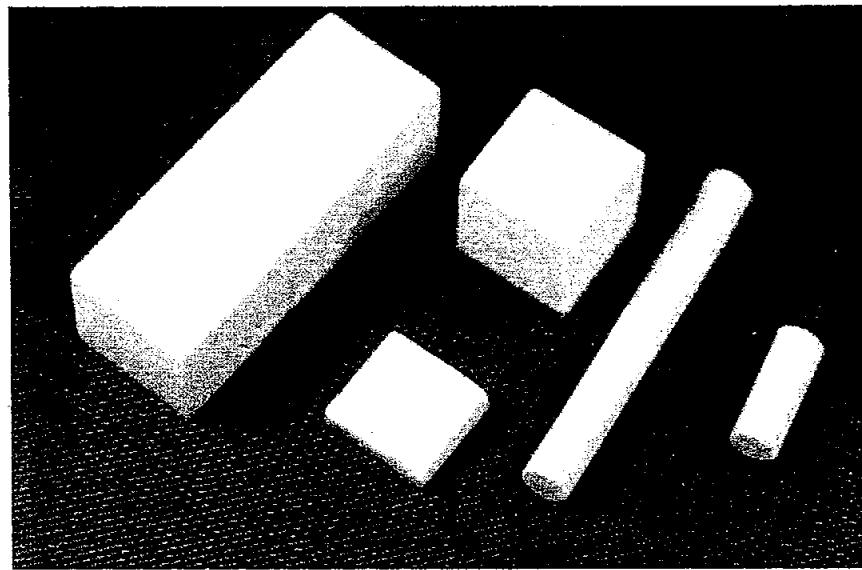
Lockheed Martin supplied six (6) different shapes/sizes of projectiles for this study. The projectiles are listed below and are displayed in Figure No. 5.

#### **[Height x Width x Length]**

- (1) 0.89" x 0.89" x 0.25" (Originally 1" diameter x 1/4" long cylinders)
- (2) 1" x 1" x 1" rectangular solids
- (3) 1" x 1" x 3" rectangular solids
- (4) 3" x 1" x 6" rectangular solids (Later eliminated from the Test Matrix)
- (5) 3/8" diameter x 1" long cylinders
- (6) 3/8" diameter x 3" long cylinders

The approximate mass of each foam projectile type is as follows:

<b>Projectile Type</b>	<b>Mass (g)</b>
0.89" x 0.89' x 0.25"	0.11
1" x 1" x 1"	0.64
1" x 1" x 3"	1.77
1" x 3" x 6" (Eliminated from the Test Matrix)	
3/8" dia. x 1"	0.08
3/8" dia. x 3"	0.23



**Figure No. 5: Foam Projectiles**

Originally, a projectile measuring 1.0" diameter x 0.25" length was to be used in this study. Because of its small length-to-diameter ratio, a sabot was needed to launch the projectile. However, upon separation of the sabot and projectile, the fragile projectile was fracturing. Due to the difficulty of launching the round projectile, the dimensions were changed to 0.89" x 0.89" x 0.25". The square projectile could be launched without a sabot, while retaining the same volume and mass as the previous selection. Tests with the 1.0" x 3.0" x 6.0" projectile were eliminated from the test matrix. The choice to eliminate this projectile was made by the sponsor, due to the establishment of a tile damage threshold early in the program with smaller projectiles.

### **3.4 Data Recording**

Test data was recorded on a standardized data sheet as shown in Figure No. 6. The data sheet contains the following information: test number, date, time, weather conditions, test personnel, orbiter tile type and condition, impact angle, projectile type and weight, gun pressures, measured velocity, damage assessment, and an area to discuss test results. Both digital and 35 mm pictures were taken of the damaged targets. Any pretest defects in the tiles such as cracking was recorded on the data sheets. The Imacon images of each test were also archived for later review.

**NASA - JSC**  
**Orbiter Tile Impact Testing**  
**SwRI Project No. 06-7503-005**

Test No. \_\_\_\_\_

Date: \_\_\_\_\_

Time: \_\_\_\_\_

Conditions: \_\_\_\_\_

Staff: \_\_\_\_\_

Target Description:

Projectile Description:

Serial No. \_\_\_\_\_

Projectile Dimensions: \_\_\_\_\_

Obliquity (deg.): \_\_\_\_\_

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: \_\_\_\_\_, P2: \_\_\_\_\_, P3: \_\_\_\_\_

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
	Ave.	_____

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

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Figure No. 6: Data Record Sheet

### 3.5 Damage Assessment

Tile damage was classified according to the extent of damage created by the foam projectile. Damage was assessed as being: **No Damage**, **Cracking of the Coating**, **Delamination of the Coating**, **Shallow Crater** (loss of coating), or as a **Crater** (loss of coating and substrate material). Tile damage was assessed by measuring the maximum dimensions (length, width and depth) of the damaged site. If applicable, the volume of the damage (crater) was measured by filling the cavity with fine glass beads of known density. By weighing the volume of glass beads needed to fill the cavity, and knowing the bead specific gravity, the volume of the cavity was calculated.

### 3.6 Test Matrix

The following tables describe the test matrix for this study. Test Sequence No. 1 is the general test matrix (Table #1). Test Sequence No. 2 is a confirmation of the general matrix (Table #2). Test Sequence No. 3 is a confirmation of prior test results (Table #3). The test matrix tables include information about the **Test Number**, **Projectile Size**, **Projectile Velocity**, and **Impact Angle**. The determination of the impact angle (the angle at which the projectile was launched against the tile target) is described in Figure No. 7. Note that a normal impact would be measured as a 90-degree incident angle.

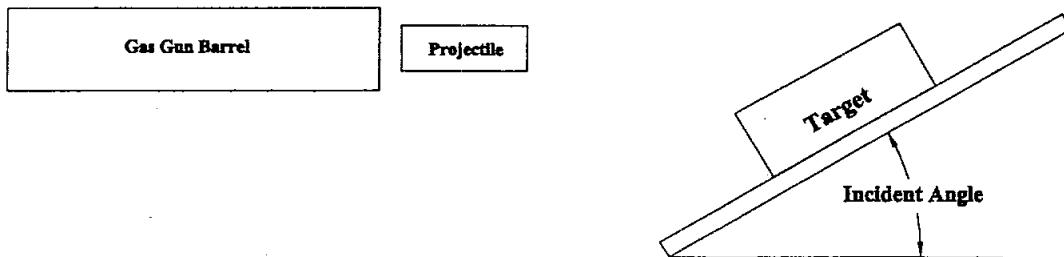


Figure No. 7: Impact Angle Diagram

During the initial stages of this study the decision was made by the sponsor to eliminate all tests with the 1.0" x 3.0" x 6.0" projectile due to the levels of damaged created by the smaller projectiles. The tests that were eliminated include Tests No. 61 through No. 80, No. 87, No. 88, No. 95, and No. 96.

**Table No. 1: Sequence No. 1 Test Matrix**

Test Number	Velocity (feet/second)	Incident Angle (degrees)	Particle Size (inches)
1	400	10	.89" x .89" x .25" rectangular solid
2	800	10	.89" x .89" x .25" rectangular solid
3	1200	10	.89" x .89" x .25" rectangular solid
4	1600	10	.89" x .89" x .25" rectangular solid
5	400	15	.89" x .89" x .25" rectangular solid
6	800	15	.89" x .89" x .25" rectangular solid
7	1200	15	.89" x .89" x .25" rectangular solid
8	1600	15	.89" x .89" x .25" rectangular solid
9	400	23	.89" x .89" x .25" rectangular solid
10	800	23	.89" x .89" x .25" rectangular solid
11	1200	23	.89" x .89" x .25" rectangular solid
12	1600	23	.89" x .89" x .25" rectangular solid
13	400	30	.89" x .89" x .25" rectangular solid
14	800	30	.89" x .89" x .25" rectangular solid
15	1200	30	.89" x .89" x .25" rectangular solid
16	1600	30	.89" x .89" x .25" rectangular solid
17	400	40	.89" x .89" x .25" rectangular solid
18	800	40	.89" x .89" x .25" rectangular solid
19	1200	40	.89" x .89" x .25" rectangular solid
20	1600	40	.89" x .89" x .25" rectangular solid

Test Number	Velocity (feet/second)	Impact Angle (degrees)	Particle Size (inches)
21	400	10	1" x 1" x 1" rectangular solid
22	800	10	1" x 1" x 1" rectangular solid
23	1200	10	1" x 1" x 1" rectangular solid
24	1600	10	1" x 1" x 1" rectangular solid
25	400	15	1" x 1" x 1" rectangular solid
26	800	15	1" x 1" x 1" rectangular solid
27	1200	15	1" x 1" x 1" rectangular solid
28	1600	15	1" x 1" x 1" rectangular solid
29	400	23	1" x 1" x 1" rectangular solid
30	800	23	1" x 1" x 1" rectangular solid
31	1200	23	1" x 1" x 1" rectangular solid
32	1600	23	1" x 1" x 1" rectangular solid
33	400	30	1" x 1" x 1" rectangular solid
34	800	30	1" x 1" x 1" rectangular solid
35	1200	30	1" x 1" x 1" rectangular solid
36	1600	30	1" x 1" x 1" rectangular solid
37	400	40	1" x 1" x 1" rectangular solid
38	800	40	1" x 1" x 1" rectangular solid
39	1200	40	1" x 1" x 1" rectangular solid
40	1600	40	1" x 1" x 1" rectangular solid

**Table No. 1 (Cont.)**

Test Number	Velocity (feet/second)	Impact Angle (degrees)	Particle Size (inches)
41	400	10	3" x 1" x 1" rectangular solid
42	800	10	3" x 1" x 1" rectangular solid
43	1200	10	3" x 1" x 1" rectangular solid
44	1600	10	3" x 1" x 1" rectangular solid
45	400	15	3" x 1" x 1" rectangular solid
46	800	15	3" x 1" x 1" rectangular solid
47	1200	15	3" x 1" x 1" rectangular solid
48	1600	15	3" x 1" x 1" rectangular solid
49	400	23	3" x 1" x 1" rectangular solid
50	800	23	3" x 1" x 1" rectangular solid
51	1200	23	3" x 1" x 1" rectangular solid
52	1600	23	3" x 1" x 1" rectangular solid
53	400	30	3" x 1" x 1" rectangular solid
54	800	30	3" x 1" x 1" rectangular solid
55	1200	30	3" x 1" x 1" rectangular solid
56	1600	30	3" x 1" x 1" rectangular solid
57	400	40	3" x 1" x 1" rectangular solid
58	800	40	3" x 1" x 1" rectangular solid
59	1200	40	3" x 1" x 1" rectangular solid
60	1600	40	3" x 1" x 1" rectangular solid

Test Number	Velocity (feet/second)	Impact Angle (degrees)	Particle Size (inches)
61	400	10	6" x 3" x 1" rectangular solid
62	800	10	6" x 3" x 1" rectangular solid
63	1200	10	6" x 3" x 1" rectangular solid
64	1600	10	6" x 3" x 1" rectangular solid
65	400	15	6" x 3" x 1" rectangular solid
66	800	15	6" x 3" x 1" rectangular solid
67	1200	15	6" x 3" x 1" rectangular solid
68	1600	15	6" x 3" x 1" rectangular solid
69	400	23	6" x 3" x 1" rectangular solid
70	800	23	6" x 3" x 1" rectangular solid
71	1200	23	6" x 3" x 1" rectangular solid
72	1600	23	6" x 3" x 1" rectangular solid
73	400	30	6" x 3" x 1" rectangular solid
74	800	30	6" x 3" x 1" rectangular solid
75	1200	30	6" x 3" x 1" rectangular solid
76	1600	30	6" x 3" x 1" rectangular solid
77	400	40	6" x 3" x 1" rectangular solid
78	800	40	6" x 3" x 1" rectangular solid
79	1200	40	6" x 3" x 1" rectangular solid
80	1600	40	6" x 3" x 1" rectangular solid

**Table #2: Sequence No. 2 Test Matrix**

Test Number	Velocity (feet/second)	Impact Angle (degrees)	Particle Size (inches)
81	800	10	1" dia. x 1/4" long cylinder
82	1600	10	1" dia. x 1/4" long cylinder
83	800	10	1" x 1" x 1" rectangular solid
84	1600	10	1" x 1" x 1" rectangular solid
85	800	10	3" x 1" x 1" rectangular solid
86	1600	10	3" x 1" x 1" rectangular solid
87	800	10	6" x 3" x 1" rectangular solid
88	1600	10	6" x 3" x 1" rectangular solid
89	800	23	1" dia. x 1/4" long cylinder
90	1600	23	1" dia. x 1/4" long cylinder
91	800	23	1" x 1" x 1" rectangular solid
92	1600	23	1" x 1" x 1" rectangular solid
93	800	23	3" x 1" x 1" rectangular solid
94	1600	23	3" x 1" x 1" rectangular solid
95	800	23	6" x 3" x 1" rectangular solid
96	1600	23	6" x 3" x 1" rectangular solid

**Table #3: Sequence No. 3 Test Matrix**

Test Number	Velocity (feet/second)	Impact Angle (degrees)	Particle Size (inches)
97	1009	60	3/8" diam. x 1" long cylinder
98	1620	30	3/8" diam. x 1" long cylinder
99	735	60	3/8" diam. x 1" long cylinder
100	960	30	3/8" diam. x 1" long cylinder
101	1206	30	3/8" diam. x 3" long cylinder
102	1181	30	3/8" diam. x 3" long cylinder
103	1025	30	3/8" diam. x 3" long cylinder
104	1200	60	3/8" diam. x 3" long cylinder

## **4.0 Test Results**

In the following section the results of the Orbiter tile impact study are presented. A limited analysis and discussion of the results are provided in this report. Further assessment of the enclosed impact test data and application of these results to the Orbiter tile damage issue will be performed by the NASA and it's supporting contractors.

The orbiter tile impact test results have been grouped in tables according to projectile type. Tables No. 4, No. 5, No. 6, and No. 7 contain the results for the .89" x .89" x .25", 3/8" dia. x 1.0" and 3/8" dia. x 3.0", 1.0" x 1.0" x 1.0", and the 1.0" x 1.0" x 3.0" projectile tests, respectively. Each table includes the following information: **Test Number, Measured Projectile Velocity, Impact Angle, Damage to the Tile (Yes or No), Damage Description, Damage Volume Measurement, and Comments.**

Graphical representations of the tile impact test results are provided in Figures No. 8, No. 9, and No. 10. In all three plots, kinetic energy [ $1/2$  mass x (velocity) $^2$ ] is used to describe the foam projectile. The shape of the foam projectiles is not taken into consideration. All data points in each plot are color coded according to the incidence angle at which the projectile impacted the tile target.

Figure No. 8 is a plot of the resulting tile damage level or category (1 – No Damage, 2 – Cracking and Delamination of the Coating, 3 – Shallow Crater, 4 – Crater) as a function of the foam projectile kinetic energy. The plot shows a general trend where the level of damage (category) increases as kinetic energy and/or incidence angle are increased. As the incidence angle reaches 60 degrees, projectiles with relatively low kinetic energy (3/8" diameter projectile in this case) can inflict high levels of damage on the tile target.

Figure No. 9 is a plot of maximum crater depth as a function of projectile kinetic energy. In general, as the incidence angle of impact is increased, crater depth increases. For a given incidence angle, crater depth increases as kinetic energy increases.

Figure No. 10 is a plot of crater volume as function of projectile kinetic energy. In general, crater volume increases as the incidence angle and/or kinetic energy are increased. As expected, tests conducted with large fast moving projectiles fired at increased incidence angles produced the largest crater volumes. Note that in several tests, the crater extended to the edge of the tile target. Thus the total possible crater volume could not be determined. Such tests are labeled with a “\*\*” symbol in the damage dimension column of the results tables. The data point for Test No. 60 in which the 1" x 1" x 3" projectile was launched at a 40 degree angle at 1432 fps is not included in the plot of Figure No. 10. The damage was too extensive to accurately measure volume.

In the plots shown in Figures No. 8, No. 9, and No. 10 there is a degree of mixed results where definite conclusions are difficult to make. The cause of the mixed results in the plots is mainly attributed to the grouping together of the data from the various shaped projectiles and due to the inherent randomness in the penetration/failure events in brittle or soft targets.

**Table No. 4: Test Results for the .89" x .89" x .25" Projectile**

Test No.	Velocity (fps)	Impact Angle (degrees)	Damage (Yes or No)	Damage Type	Damage Max. Dimensions (Length x Wide x Depth)	Comments	Damage Volume (cubic inches)
1	441	10	No	*****	*****	Velocity (+41 fps)	*****
2	975	10	No	*****	*****	Velocity (+175 fps)	*****
3	1166	10	No	*****	*****	Velocity (-34 fps)	*****
4 (B)	1550	10	No	*****	*****	Velocity (-50 fps)	*****
5	731	15	No	*****	*****	Velocity (+331 fps)	*****
6	952	15	No	*****	*****	Velocity (+152 fps)	*****
7	1279	15	No	*****	*****	Velocity (+79 fps)	*****
8	1606	15	Yes	Delamination and Cracking of Coating	1.0" Diameter	Velocity (+6 fps),	0.02
9	579	23	No	*****	*****	Velocity (+179 fps)	*****
10	794	23	No	*****	*****	Velocity (-6 fps)	*****
11	1257	23	Yes	Delamination and Cracking of Coating	0.94" Diameter	Velocity (+57 fps)	*****
12	1490	23	Yes	Delam., Cracking, Loss of Coating	1.25" Diameter	Velocity (-110 fps)	0.04
13	552	30	No	*****	*****	Velocity (+152 fps)	*****
14	825	30	No	*****	*****	Velocity (+25 fps)	*****
15 (A)	1160	30	Yes	Shallow Crater, Loss of Coating	0.94 x 1.25" x 0.13"	Velocity (-40 fps)	0.03
16 (B)	1605	30	Yes	Crater	1.34" x 1.1" x 0.26"	Velocity (+5 fps)	0.13
17	516	40	No	*****	*****	Velocity (+116 fps)	*****
18	799	40	Yes	Delamination and Cracking of Coating	0.66" x 0.98"	Velocity (-1 fps)	*****
19 (D)	1252	40	Yes	Crater	1.0" x 1.1" x 0.41"	Velocity (+52 fps)	0.19
20 (F)	1520	40	Yes	Crater	1.44" x 1.2" x 0.47"	Velocity (-80 fps)	0.24
81	750	10	No	*****	*****	Velocity (-50 fps)	*****
82	1553	10	No	*****	*****	Velocity (-47 fps)	*****
89	785	23	No	*****	*****	Velocity (-15 fps)	*****
90 (B)	1640	23	Yes	Shallow Crater, Loss of Coating	1.1" x 1.15" x 0.11"	Velocity (+40 fps)	0.03

**Table No. 5: Test Results for the 3/8" Diameter Projectiles**

Test No.	Projectile	Velocity	Impact Angle	Damage	Damage Type	Damage Max. Dimensions (Length x Wide x Depth)	Comments	Damage Volume (cubic inches)
	Length	(fps)	(degrees)	(Yes or No)				
97	1.0"	1000	60	Yes	Crater	0.53" dia. X 0.35" deep	Velocity (-9 fps), This is the New Test 97	0.05
98 (A)	1.0"	1692	30	Yes	Crater	1.07" x 0.56" x 0.36"	Velocity (+72 fps), New Test 98A	0.10
99 (B)	1.0"	730	60	Yes	Crater	0.62" dia. x 0.15" deep	Velocity (-5 fps), This is the New Test 99B	0.02
100	1.0"	929	30	No	*****	*****	Test No. 97 in NoteBook, Vel (-31 fps)	*****
101 (B)	3.0"	1317	30	Yes	Crater	1.85" x 1.08" x 0.5"	Velocity (+111 fps), New Test 101B	0.18
102	3.0"	1317	30	Yes	Crater	1.85" x 1.08" x 0.5"	Velocity (+111 fps), New Test 101B	0.18
103	3.0"	1071	30	Yes	Crater	1.5" x 1.0" x 0.5"	Velocity (+46 fps), New Test 103	0.17
104	3.0"	1250	60	Yes	Crater	1.01" dia. X 0.9" deep	Velocity (+50 fps), New Test 104, Proj. Slightly Broekn Up	0.15

**Table No. 6: Test Results for the 1.0" x 1.0" x 1.0" Projectile**

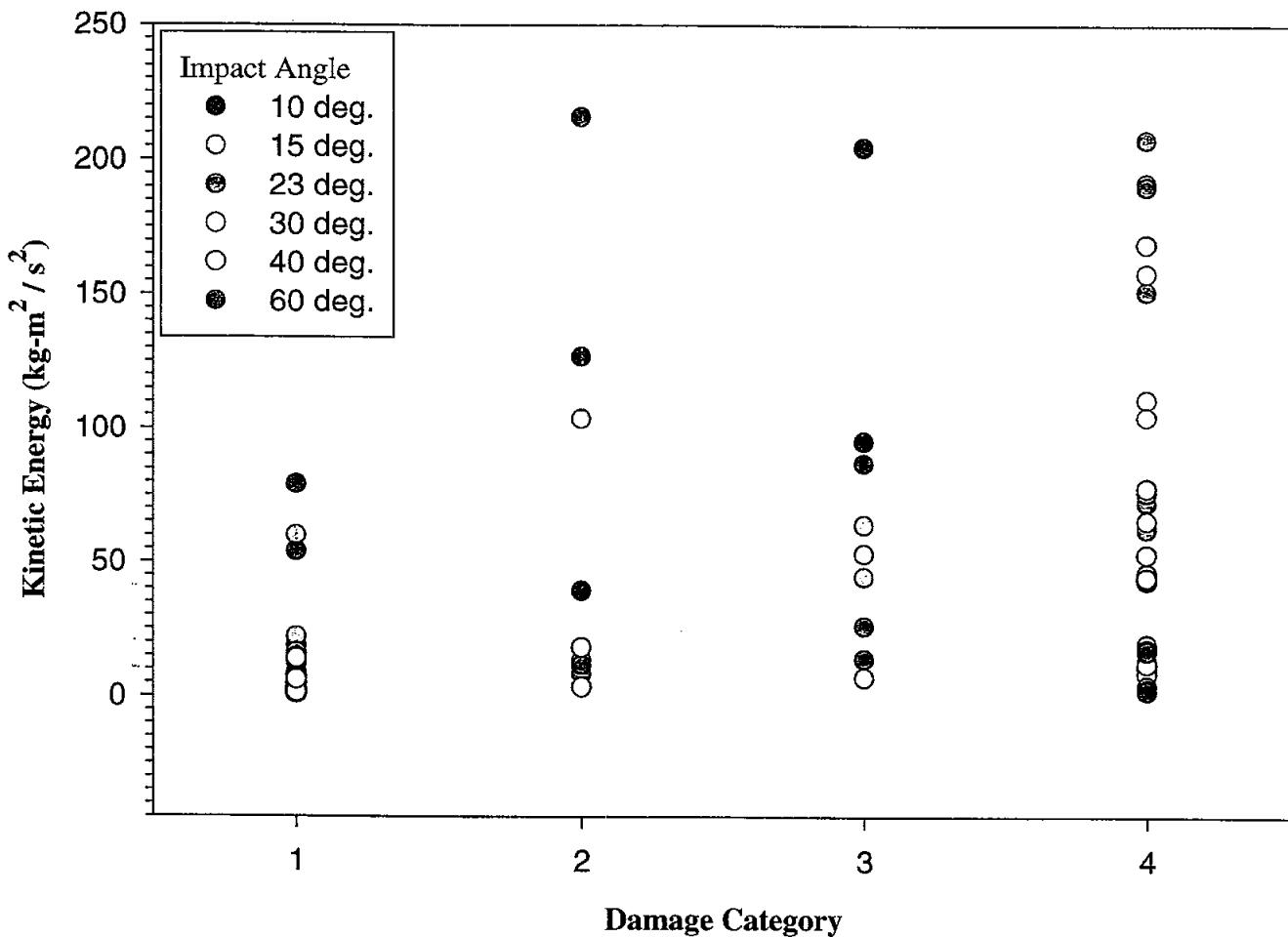
Test No.	Velocity (fps)	Impact Angle (degrees)	Damage (Yes or No)	Damage Type	Damage Max. Dimensions (Length x Wide x Depth)	Comments	Damage Volume (cubic inches)
21	338	10	No	*****	*****	Velocity (-62 fps)	*****
22	670	10	No	*****	*****	Velocity (-130 fps)	*****
23	1147	10	Yes	Coating Cracking	one small crack	Velocity (-53 fps)	*****
24 (F)	1788	10	Yes	Shallow Crater, loss of Coating	2.0" x 2.5" x 0.1"	Velocity (+188 fps)	0.11
25	490	15	No	*****	*****	Velocity (+90 fps)	*****
26 (A)	856	15	No	*****	*****	Velocity (+56 fps)	*****
27	1221	15	Yes	Shallow Crater, loss of Coating	1.25" x 2.5" x 0.1"	Velocity (+21 fps)	0.11
28 (B)	1465	15	Yes	Shallow Crater, loss of Coating	2.0" x 2.0" x 0.1"	Velocity (-135 fps), Projectile Slightly Broken Up	0.10
29	353	23	No	*****	*****	Velocity (-47 fps)	*****
30 (B)	934	23	Yes	Shallow Crater, loss of Coating	1.0" x 2.0" x 0.1"	Velocity (+134 fps)	0.05
31	1233	23	Yes	Crater	**1.25" x 2.25" x 0.25"	Velocity (+33 fps), Extended to Tile Edge	0.34
32	1557	23	Yes	Crater	3.75" x 1.5" x 0.4"	Velocity (-43 fps)	0.64
33	452	30	No	*****	*****	Velocity (+52 fps)	*****
34 (A)	805	30	Yes	Crater	2.0" x 1.25" x 0.25"	Velocity (+5 fps)	0.13
35	1240	30	Yes	Crater	2.25" x 1.38" x 0.4"	Velocity (+40 fps), Projectile Cracked	0.47
36 (A)	1483	30	Yes	Crater	2.5" x 1.5' x 0.5"	Velocity (-117 fps), Projectile Slightly Broken Up	0.58
37	447	40	No	*****	*****	Velocity (+47 fps)	*****
38	767	40	Yes	Crater	1.5" x 1.25" x 0.38"	Velocity (-33 fps), Projectile lost a small piece	0.21
39	1216	40	Yes	Crater	2.5" x 1.1" x 0.5"	Velocity (+16 fps)	0.65
40 (A)	1616	40	Yes	Crater	3.0" x 1.5" x 0.5"	Velocity (+16 fps), Projectile Slightly Broken Up	0.61
83	790	10	No	*****	*****	Velocity (-10 fps)	*****
84 (B)	1710	10	Yes	Shallow Crater, loss of Coating	**2.25" x 1.63" x 0.10"	Velocity (+110), Extended to Tile Edge	0.08
91	794	23	Yes	Crater	1.7" x 1.21" x 0.24"	Velocity (-6 fps)	0.17
92	1596	23	Yes	Crater	3.35" x 1.4" x 0.40"	Vel. (-4 fps), Proj. Slightly Broken Up	0.67

\*\* Crater Extended to Tile Edge

**Table No. 7: Test Results for the 1.0" x 1.0" x 3.0" Projectile**

Test No.	Velocity	Impact Angle	Damage	Damage Type	Damage Max. Dimensions	Comments	Damage Volume
	(fps)	(degrees)	(Yes or No)		(Length x Wide x Depth)		(cubic inches)
41	409	10	No	*****	*****	Velocity (+9 fps)	*****
42	809	10	No	*****	*****	Velocity (+9 fps)	*****
43	1242	10	Yes	Very Slight Cracking at Impact site	*****	Velocity (+42 fps)	*****
44	1620	10	Yes	Very Slight Cracking at Tile edge	*****	Velocity (+20 fps), Projectile Slightly Broken Up	*****
45	399	15	No	*****	*****	Velocity (- 1 fps)	*****
46	853	15	No	*****	*****	Velocity (+53 fps)	*****
47 (A)	1122	15	Yes	Delamination and Cracking of Coating	1.5" x 1.0"	Velocity (-78 fps)	*****
48 (C)	1526	15	Yes	Crater	**3.35" x 1.25" x 0.5"	Velocity (-74 fps), Extended to Tile Edge	0.86
49	440	23	No	*****	*****	Velocity (+40 fps)	*****
50 (A)	723	23	Yes	Crater	1.8" x 1.1" x 0.2"	Velocity (-67 fps)	0.29
51 (B)	1356	23	Yes	Crater	**4.25" x 1.3" x 0.63"	Velocity (+156 fps), Extended to Tile Edge	2.51
52 (B)	1588	23	Yes	Crater	**4.0" x 1.1" x 0.8"	Velocity (-12 fps), Extended to Tile Edge	2.59
53	410	30	No	*****	*****	Velocity (+10 fps)	*****
54	803	30	Yes	Shallow Crater, Loss of Coating	2.0" x 1.25" x 0.08"	Velocity (+3 fps)	0.17
55	1161	30	Yes	Crater	**3.65" x 1.5" x .75"	Velocity (-39 fps), Extended to Tile Edge	2.01
56	1386	30	Yes	Crater	4.13" x 2.75" x 0.6"	Velocity (-214 fps), Projectile Slightly Broken Up	1.83
57 (A)	467	40	Yes	Delamination and Cracking of Coating	0.75" diameter x 0.13" deep	Velocity (+67 fps)	0.01
58	801	40	Yes	Crater	2.5" x 1.2" x 0.4"	Velocity (+1 fps)	0.76
59 (A)	1126	40	Yes	Crater	4.5" x 2.0" x 1.0"	Velocity (-74 fps)	2.30
60	1432	40	Yes	Crater	**6.0" x 3.0" x 2.0"	Velocity (-168 fps), Projectile Broke Up	Unmeasurable
85	980	10	No	*****	*****	Velocity (+180 fps)	*****
86	1577	10	Yes	Shallow Crater, Loss of Coating	**2.56" x 1.7" x 0.11"	Velocity (-23 fps)	0.13
93	870	23	Yes	Crater	2.25" x 1.32" x 0.27"	Velocity (+70 fps)	0.37
94 (A)	1520	23	Yes	Crater	**5.02" x 1.61" x 0.65"	Velocity (-80 fps), Slightly Cracked Proj.	2.02

\*\* Crater Extended to Tile Edge



(1-No Damage, 2-Cracking and Delamination of Coating, 3-Shallow Crater, 4-Crater)

**Figure No. 8: Projectile Kinetic Energy vs. Damage Category**

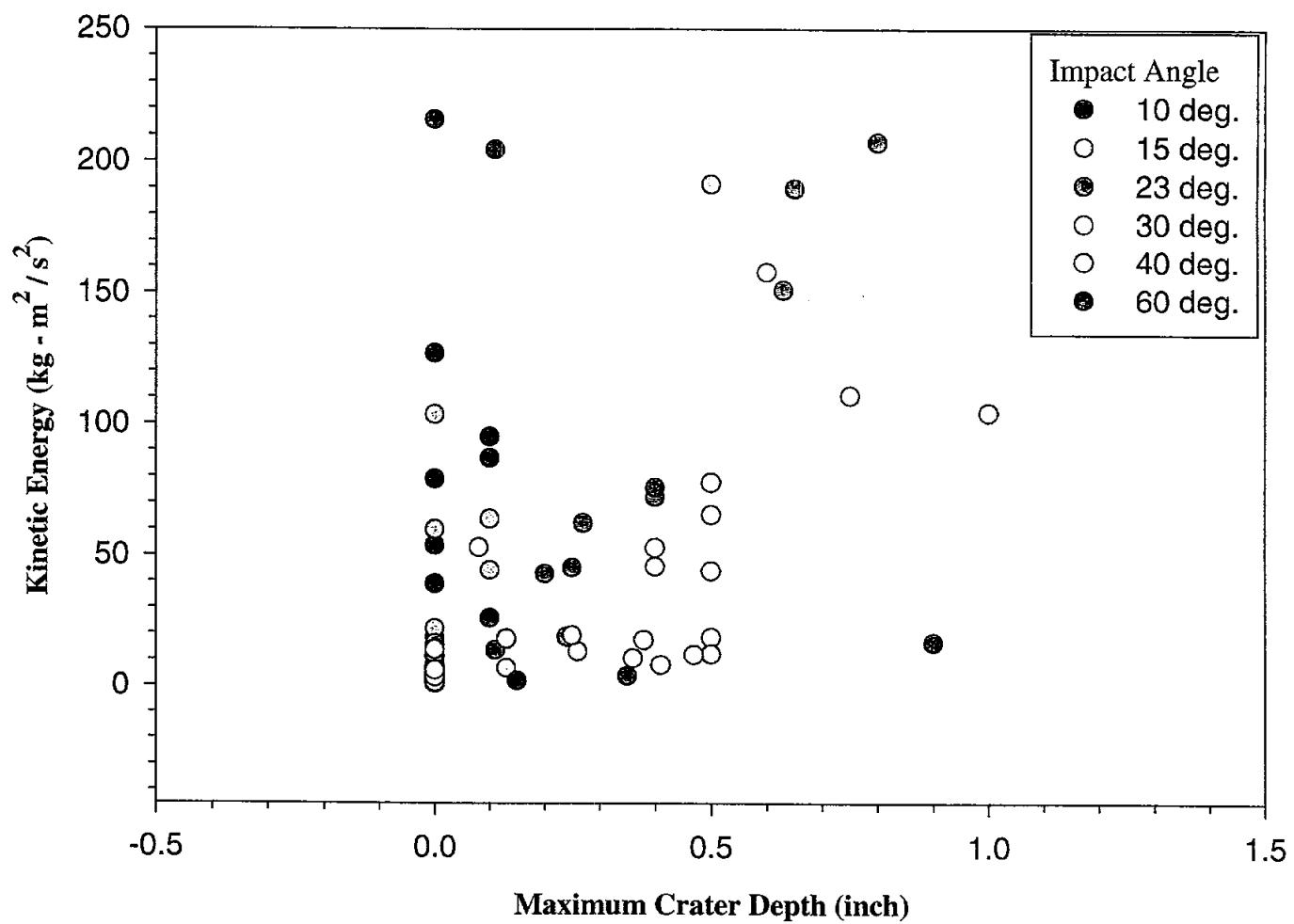


Figure No. 9: Projectile Kinetic Energy vs. Max. Crater Depth

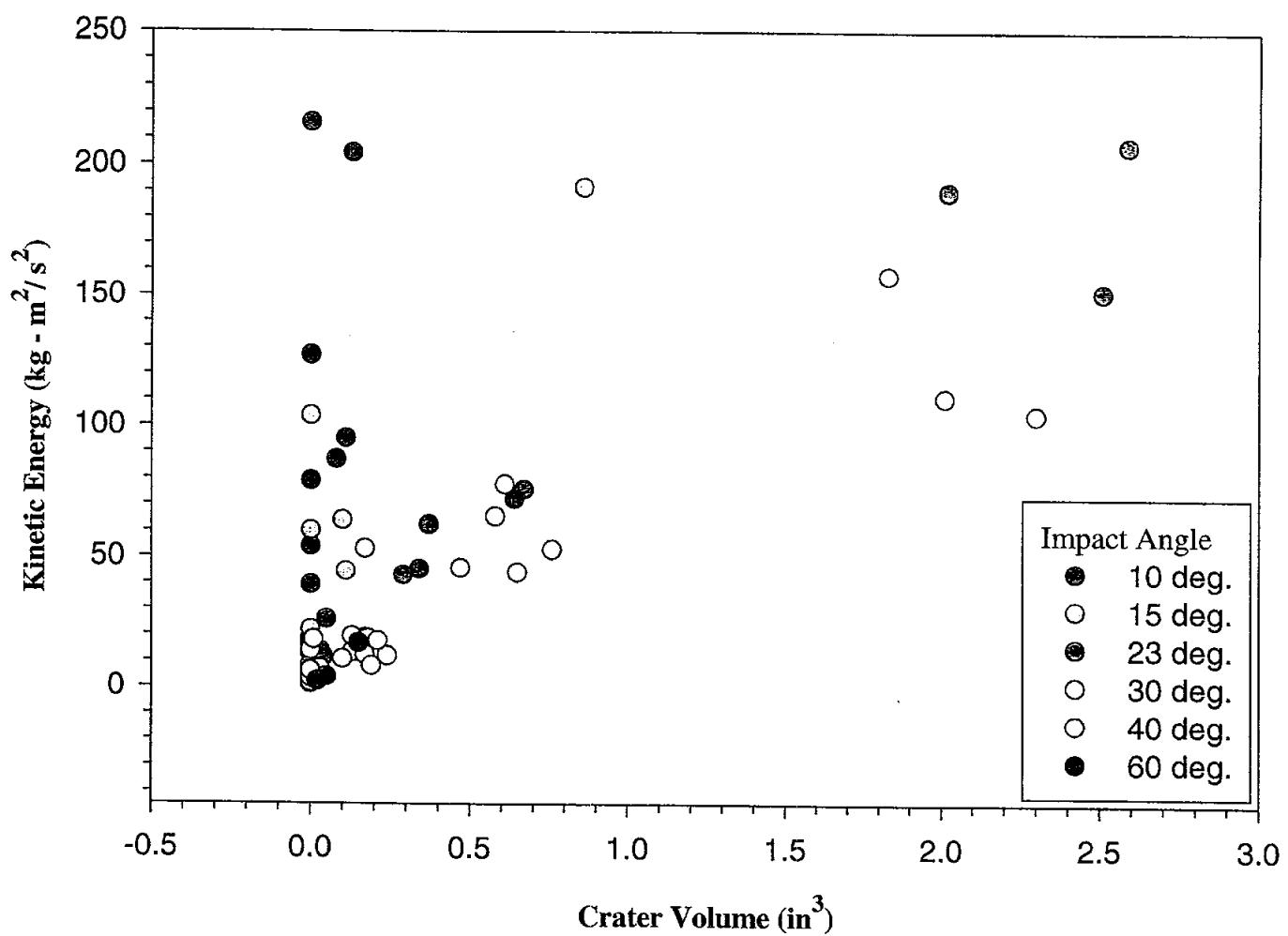


Figure No. 10: Projectile Kinetic Energy vs. Crater Volume

Photographic records of the damaged tiles are given in Appendix A. On most tiles, multiple tests were conducted. The test number for a given damage site has been written above or below the damage site. Figure No. 11 is an example of an impacted tile with test number labeling. Data Record Sheets for each test are given in Appendix B.



**Figure No. 11: Photograph of damaged tile**

During the performance of certain tests, circumstances occurred that required the test to be repeated. Reasons for repeating a test included too slow or too fast projectile velocity, no velocity reading due to a malfunction of the trigger for the Imacon Imaging System, or damage to the projectile during launch. If tile damage was sustained during a test in which something like this occurred, the results were recorded and the test repeated. Each subsequent test was given a letter suffix (i.e.: Test No. 40A). Thus, if several attempts were required to meet the criteria of a specific test, the last test would be the official test. When a velocity reading could not be

measured, an estimated velocity based on the database of velocities was recorded. The estimated velocity values are considered to be fairly accurate since the chamber pressure of the gun was known and the system is very repeatable. A table describing all the tests conducted (131 total tests) is given in Appendix C. An asterisk has been placed by the official test number in the combined result table.

The Imacon images recorded for each test are provided in Appendix D. All valid Imacon records are given with all eight images printed on a single page. An example set of the eight Imacon images, expanded to full-page size, has been provided for each projectile type in Appendix E. The eight full size Imacon images of a 1" x 1" x 3" projectile breaking up before impact are also given (Test No. 60).

Per the sponsor's request, two additional tests (Tufi-1 and Tufi-2) were conducted on a different type of thermal protection tile known as the Toughened Unipiece Fiberous Insulation or TUFI tile. The results of these two tests are also included in the combined test results table in Appendix C.

## **Section 5.0: Conclusions**

In this program the effects of impacting Orbiter HRSI tiles with NCFI 24-124 foam projectiles, launched at various incidence angles and velocities, were successfully studied. The damage capability of the foam projectiles was determined. From these test results, comparisons to previously conducted

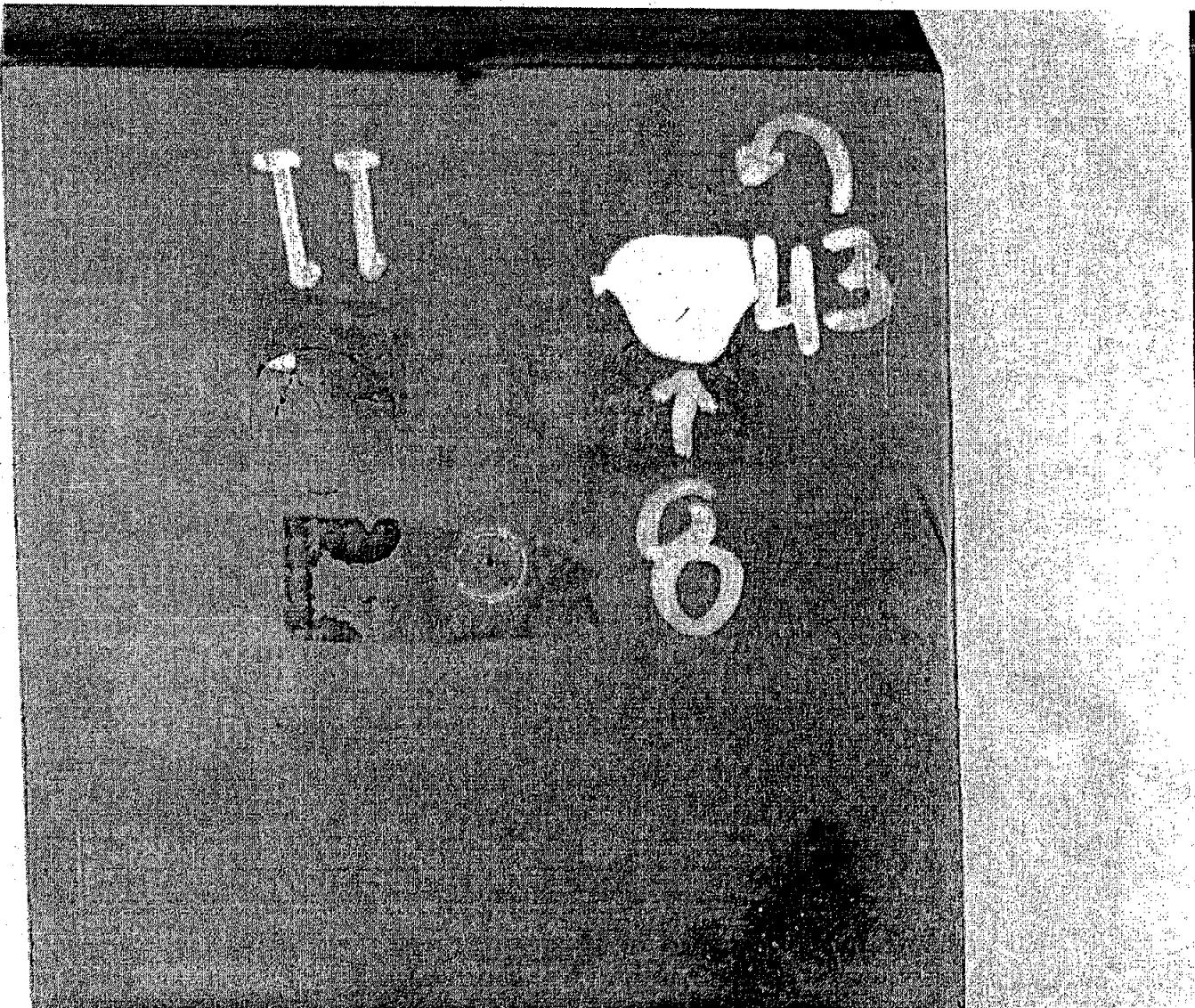
0tests can be made.

All scheduled tests were completed for each of the projectile types as described in the test matrix. The series of tests with the large 1" x 3" x 6" foam projectiles was eliminated due to the establishment of a tile damage threshold early in the program with smaller projectiles.

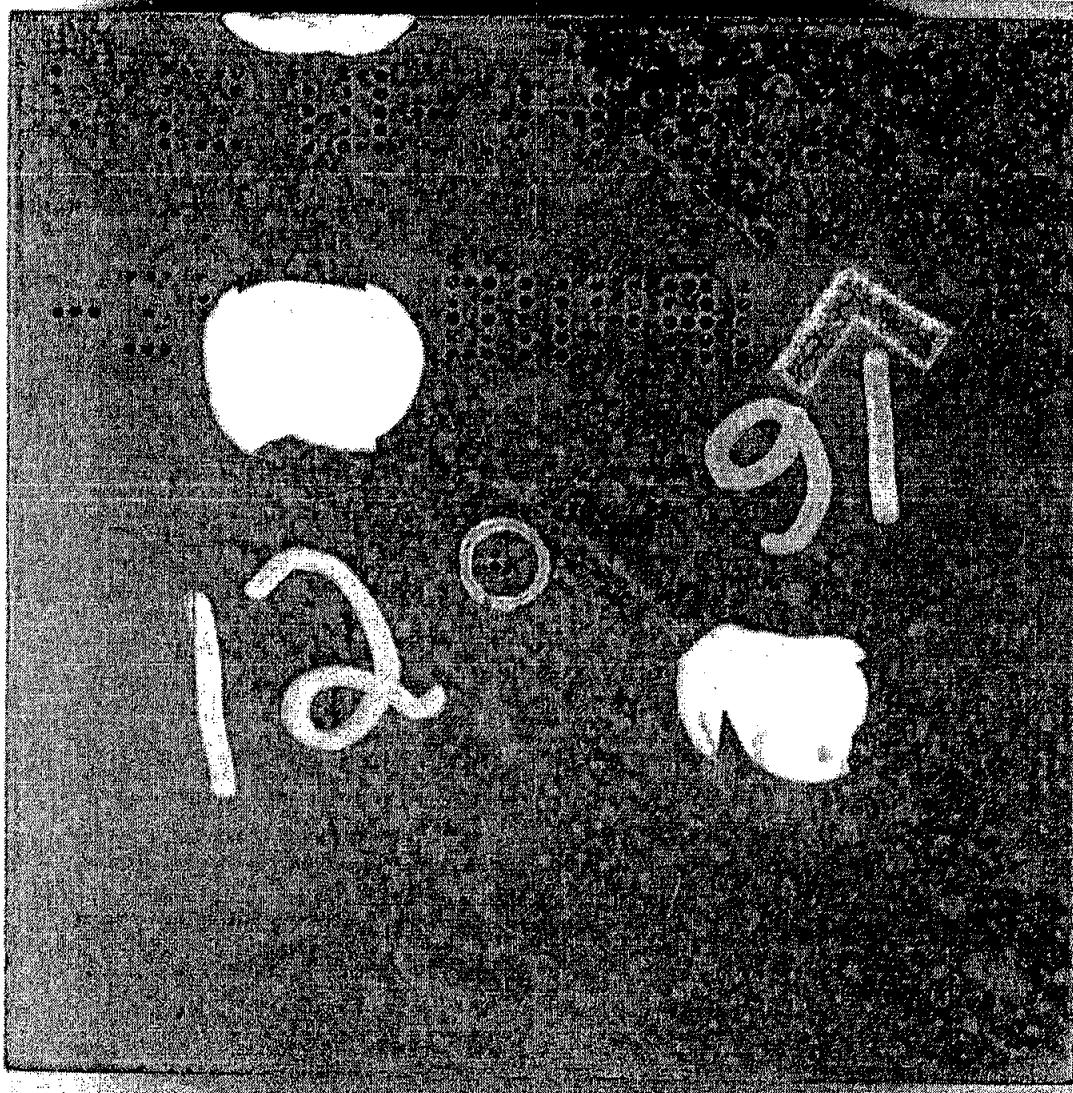
The use of the ultra high speed Imacon 468 digital camera proved to be a very valuable aid in diagnosing the experiments. The digital camera was used to measure the velocity of the projectile as well as provide visual evidence of the pre-impact integrity of the fragile foam projectiles. Visual analysis of the foam projectile impacting the tile target was also possible with the Imacon camera.

The last important remark that should be made addresses the use of the compressed gas gun for launching the fragile foam projectiles. Preliminary testing proved that the best method of launching the various size foam projectiles was to use custom barrels that were designed with bores that dimensionally match the cross section of the projectile. A projectile that fits in the custom barrel properly eliminates the need for a sabot carrier. The difficulty with using a sabot lies in the removal of the sabot prior to the foam impacting the target. It was almost impossible to reach high velocities and not fracture the fragile foam projectile or launch some part of the sabot. With such a lightweight projectile, sabot pieces can cause more severe damage than the foam. All projectile types in the study were successfully launched without the use of a sabot. However, as testing velocities reached 1600 fps, some projectiles began to break up due to the fragile nature of the foam material.

**APPENDIX A:**  
**PHOTOGRAPHIC RECORDS**  
**OF DAMAGED TILES**



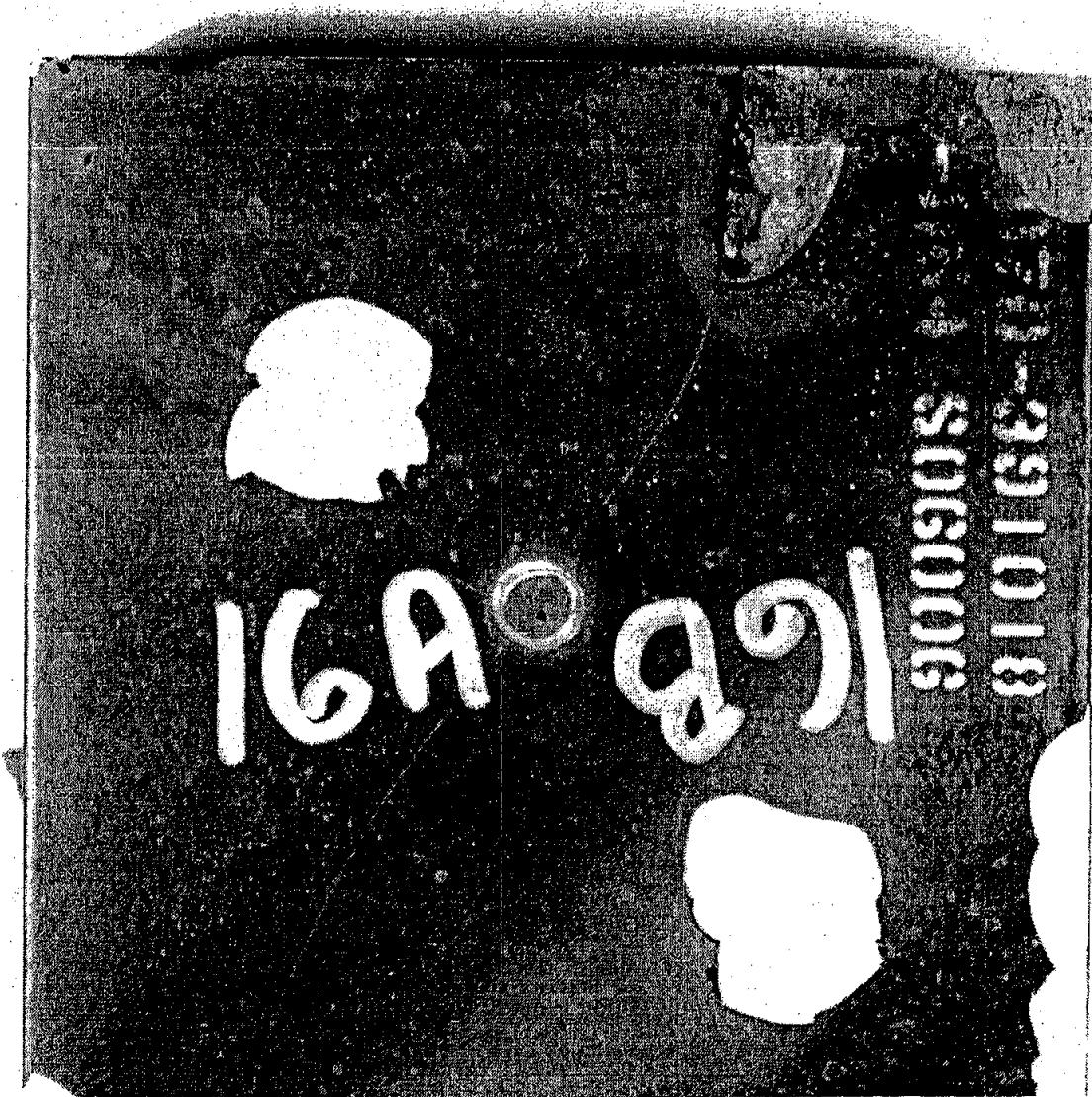
Tests No. 8, 11, and 43



Tests No. 12 and 16



Tests No. 15 and 15A



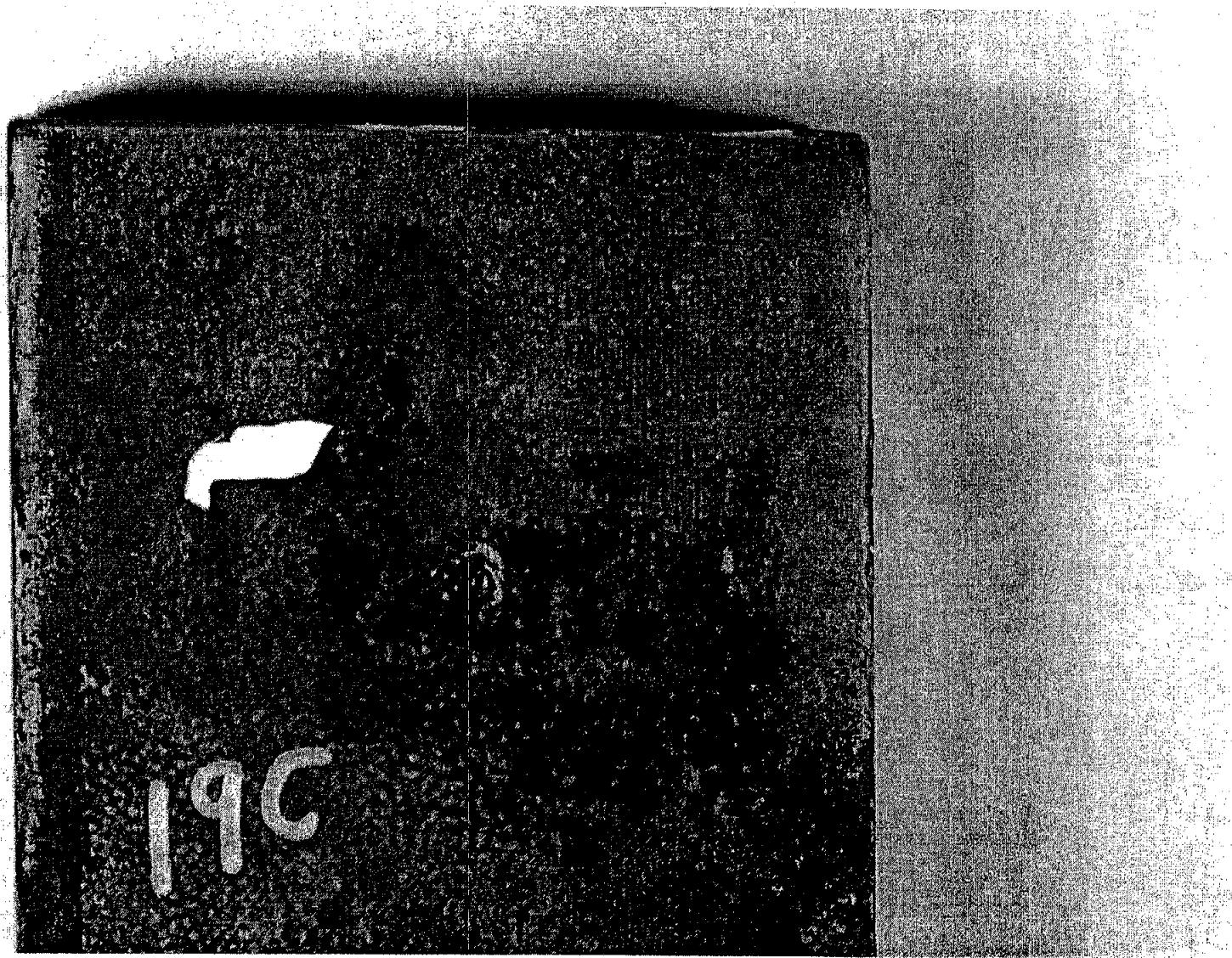
Tests No. 16A and 16B



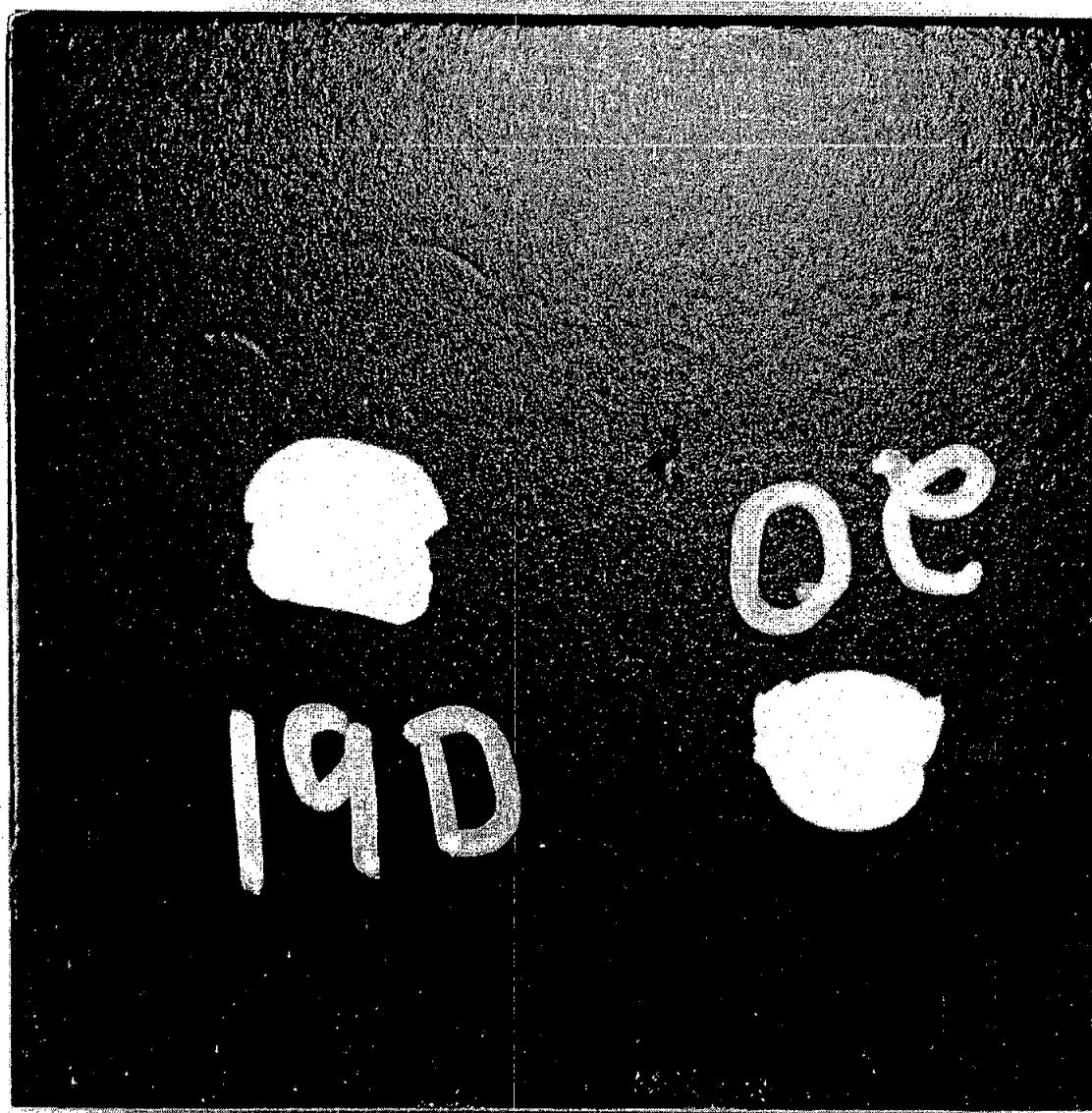
Tests No. 18 and 19



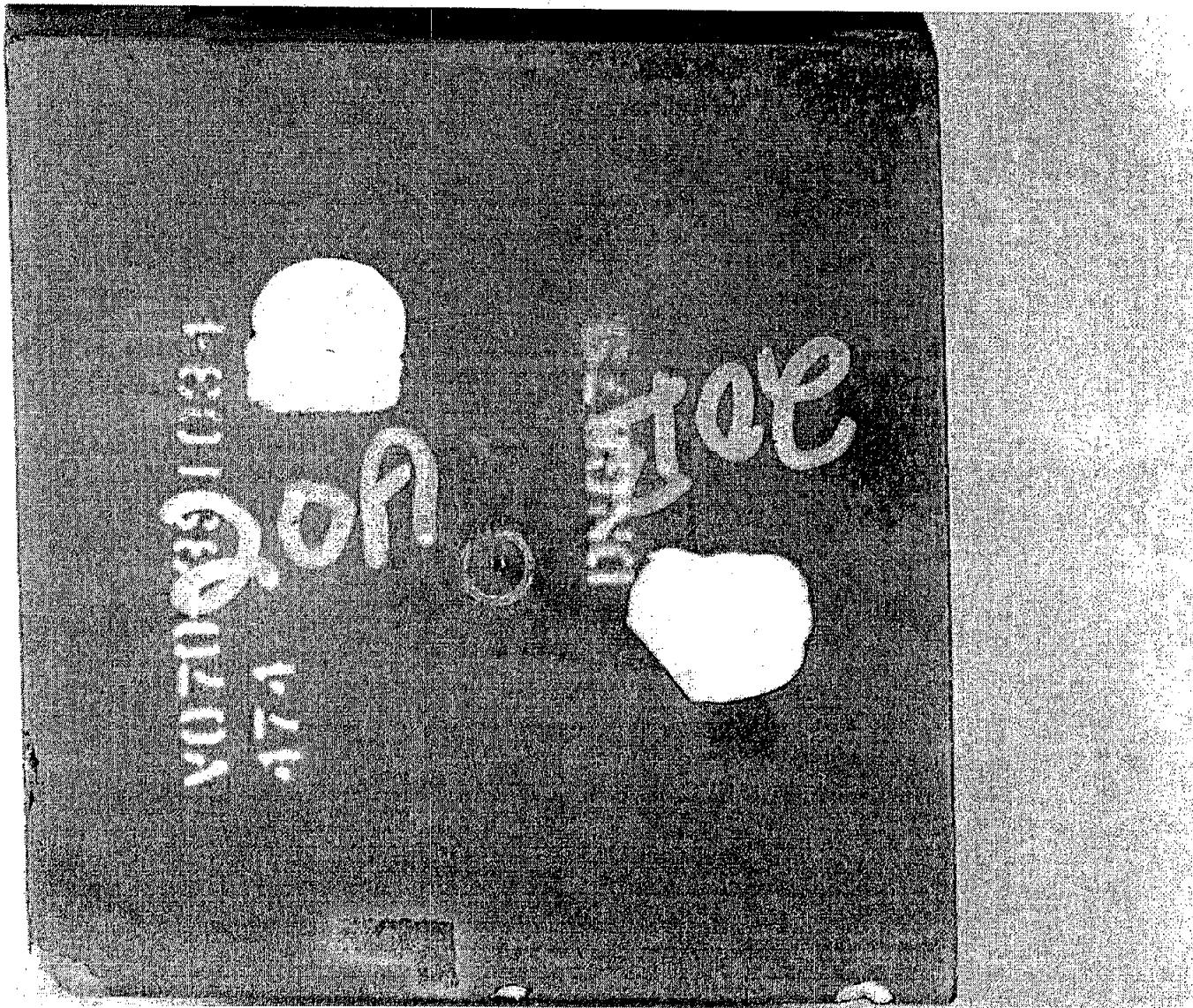
Tests No. 19A and 19B



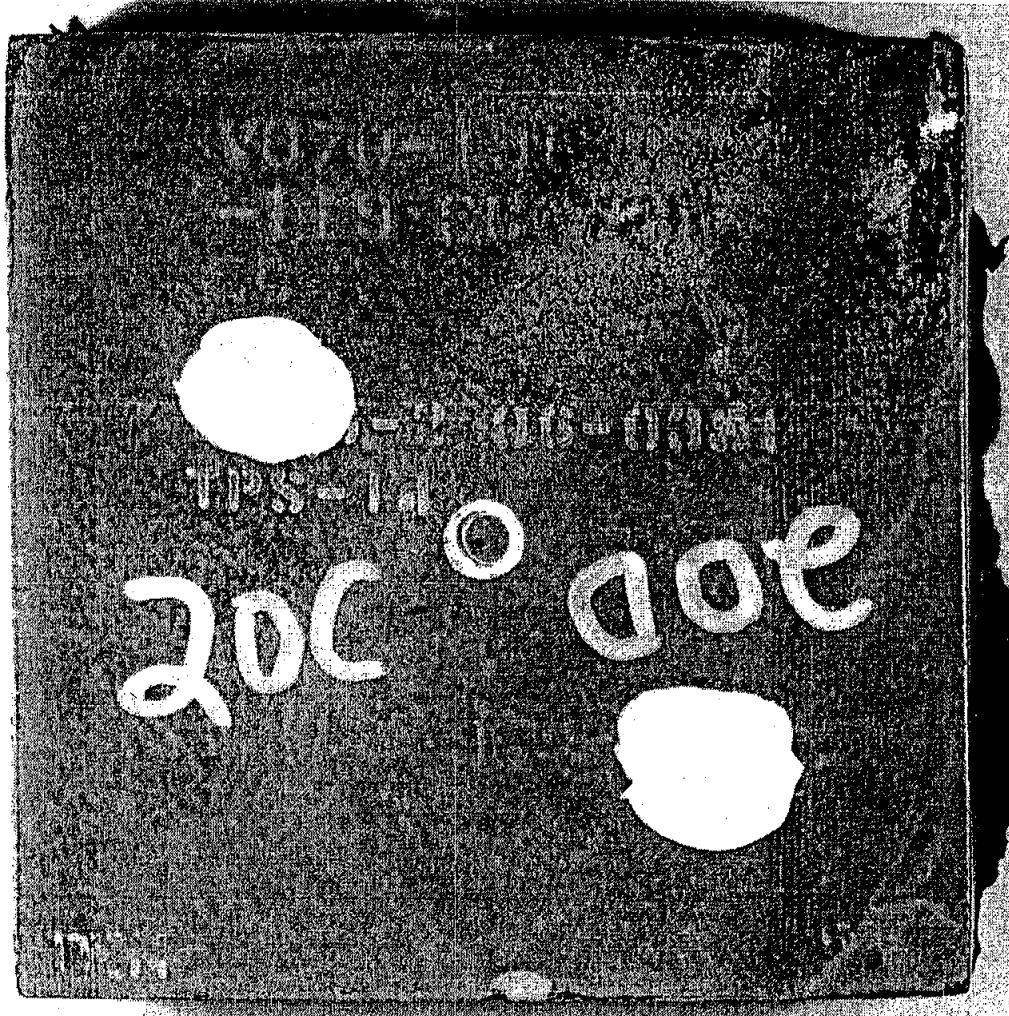
**Test No. 19C**



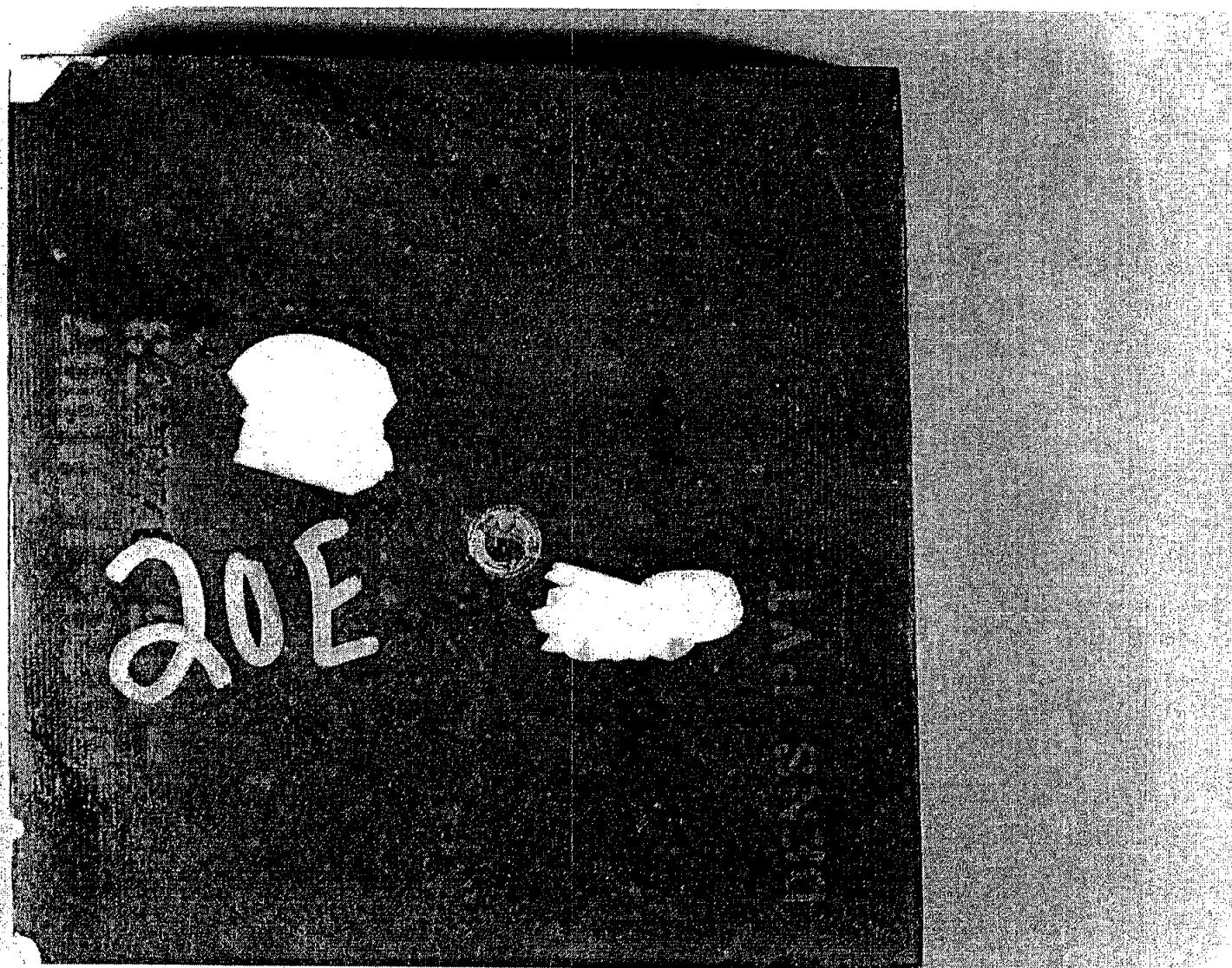
Tests No. 19D and 20



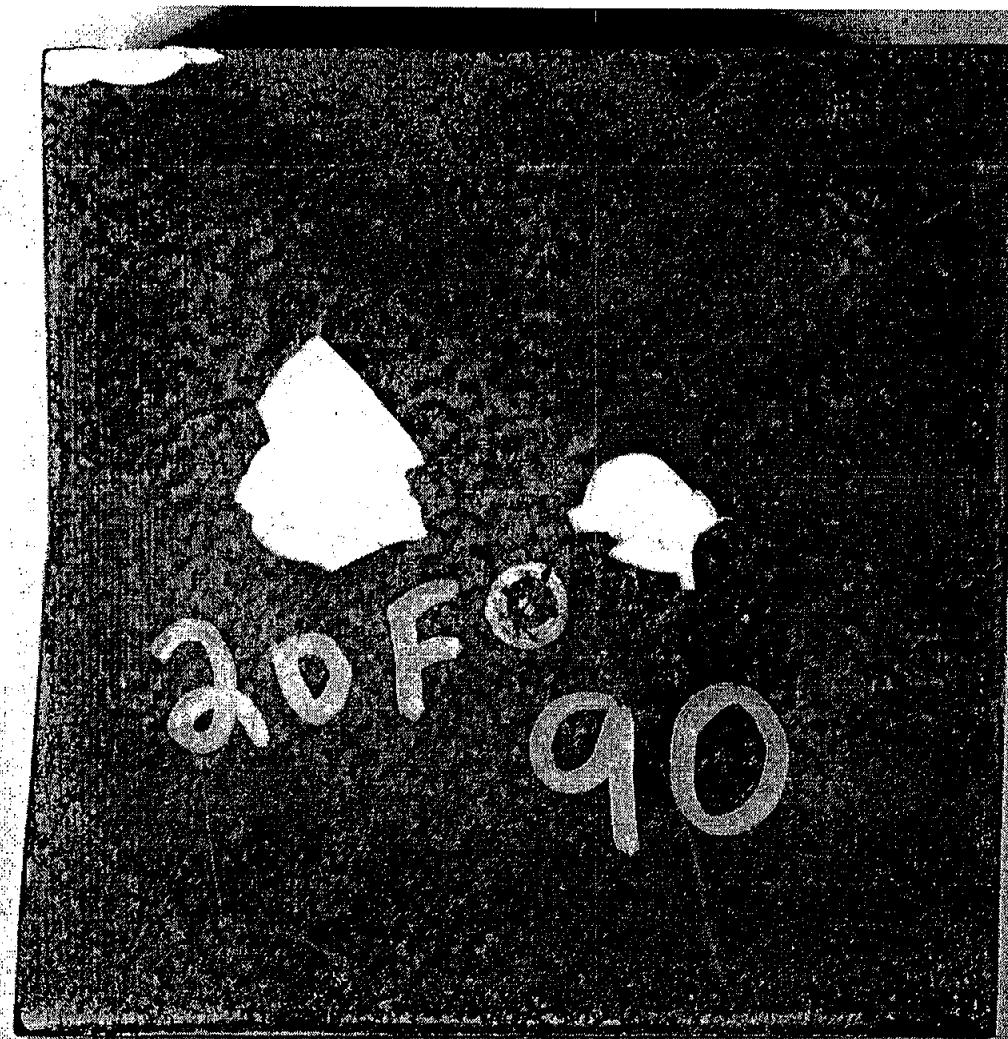
Tests No. 20A and 20B



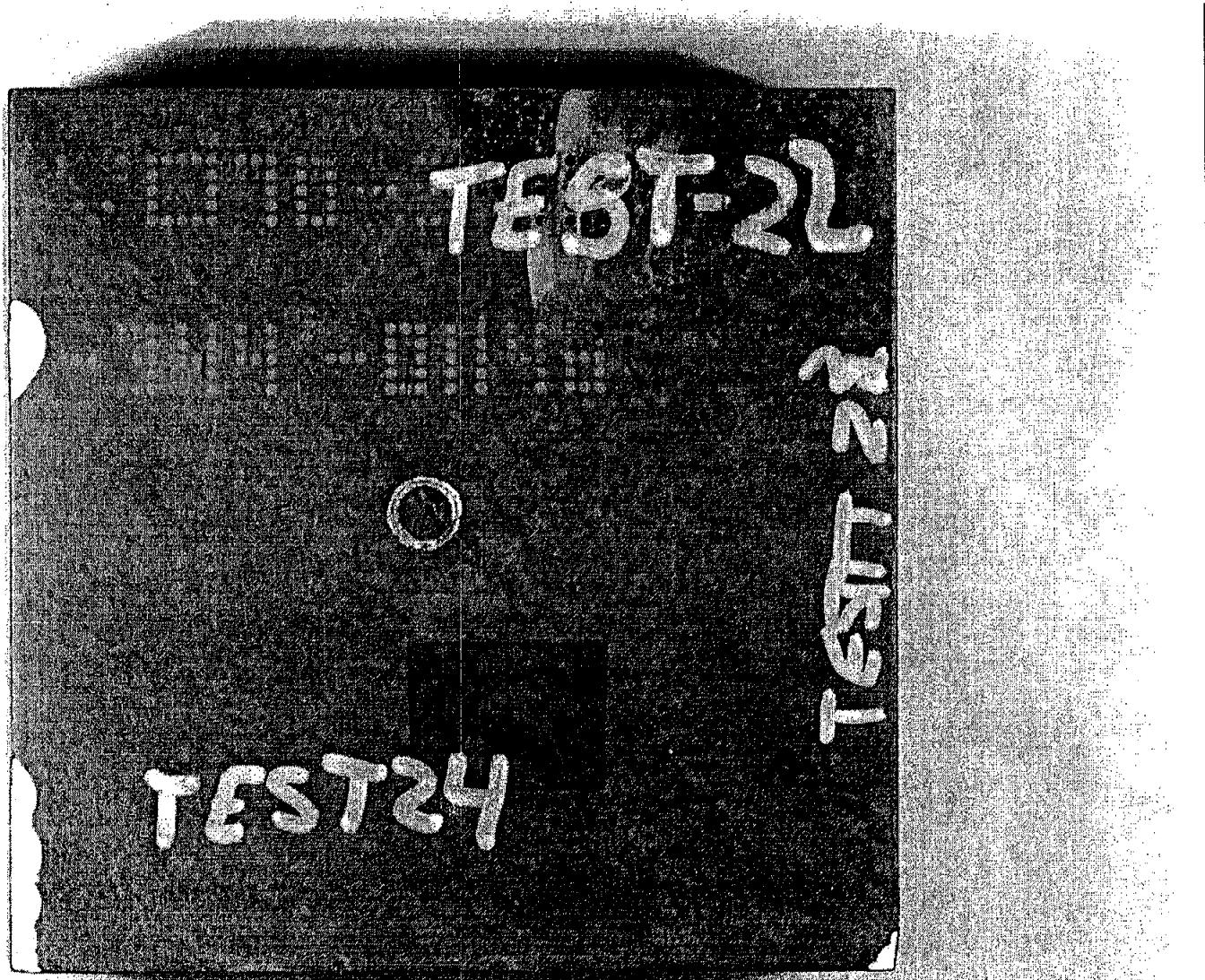
Tests No. 20C and 20D



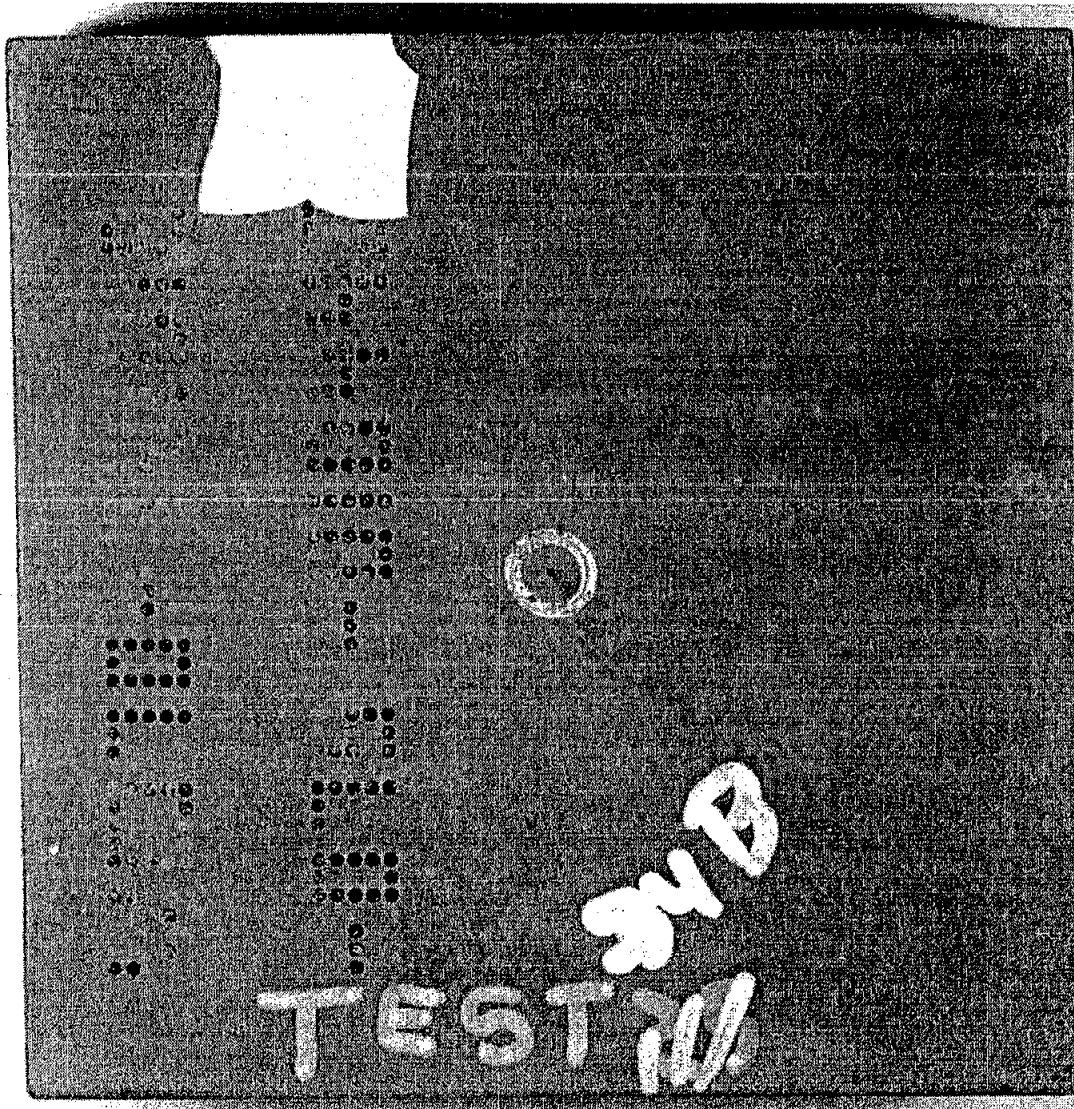
**Test No. 20E**



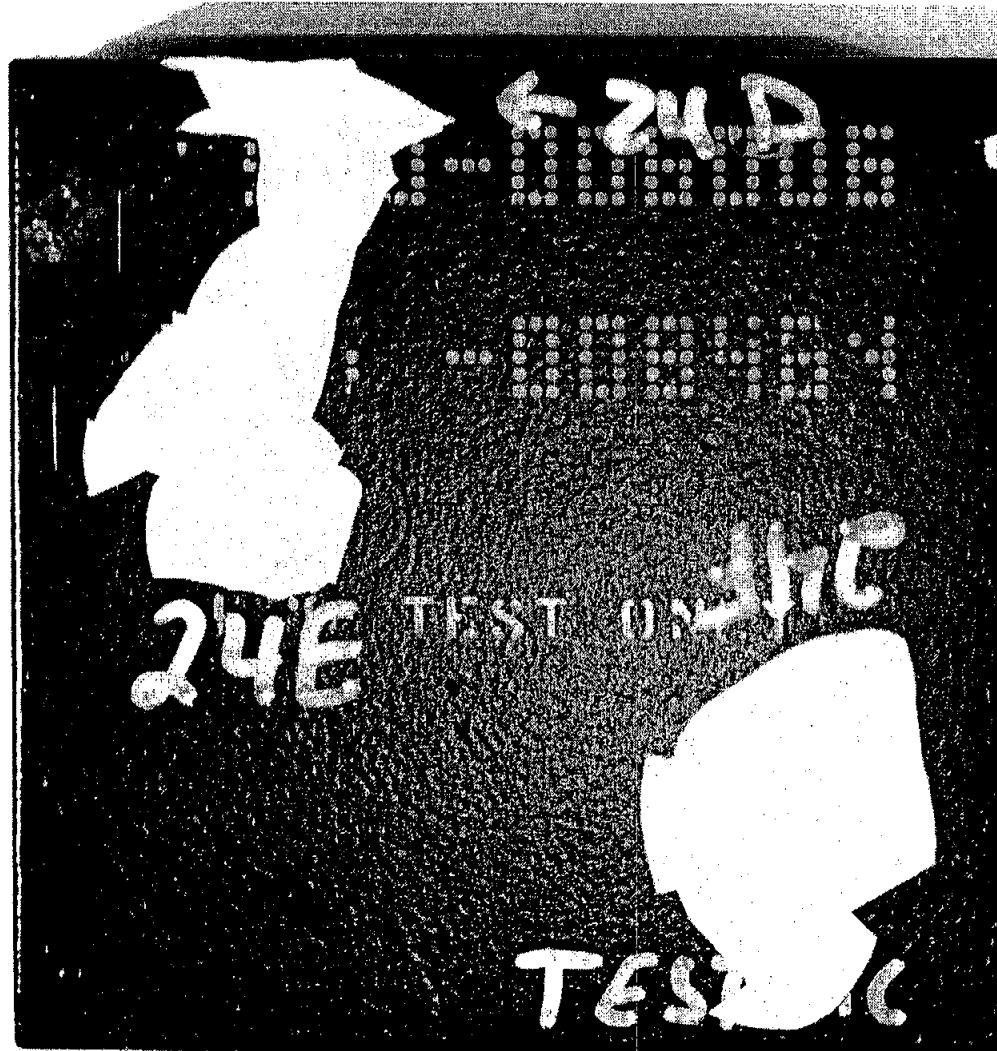
Tests No. 20F and 90



Tests No. 22, 23, and 24



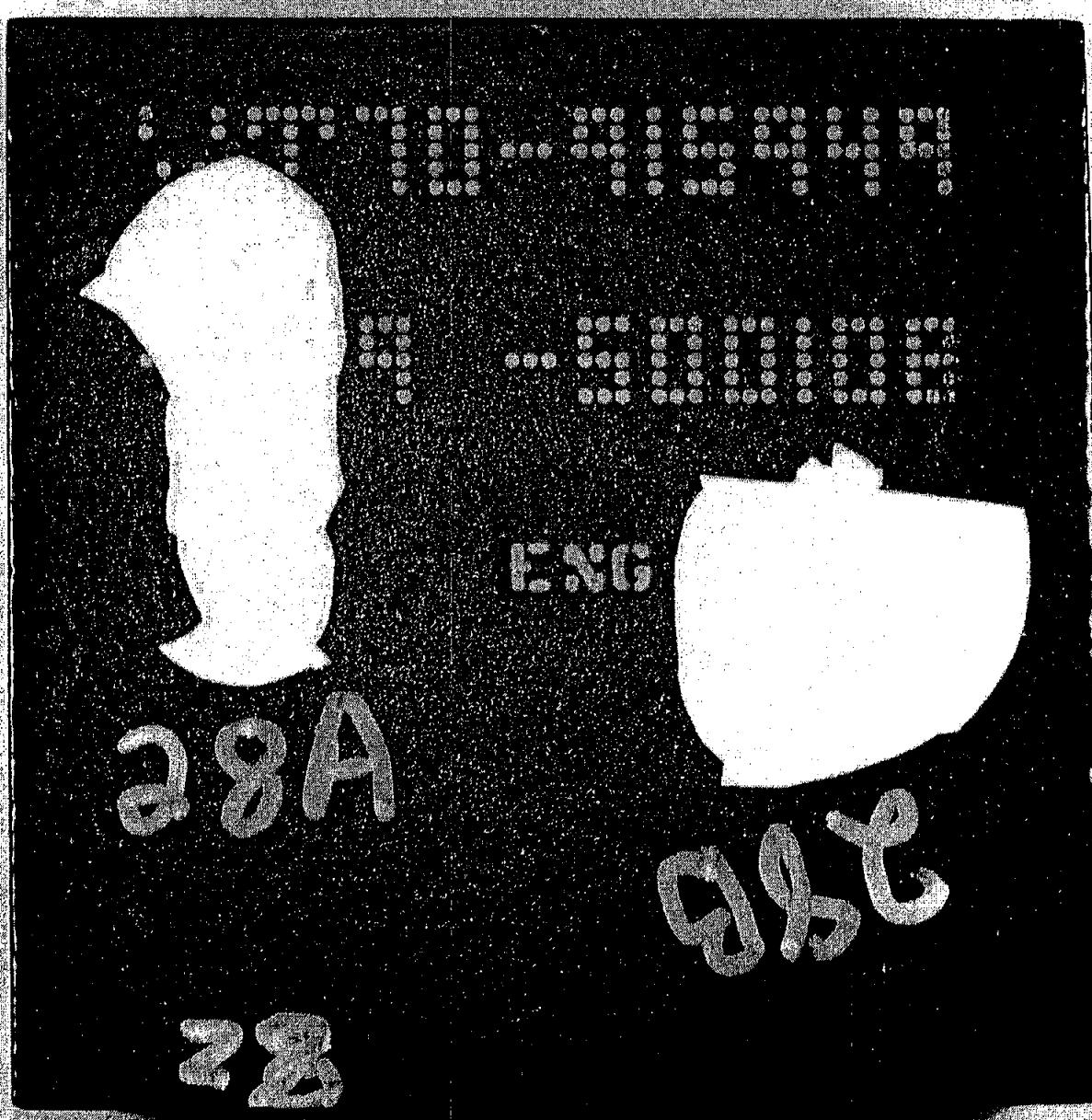
Test No. 24B



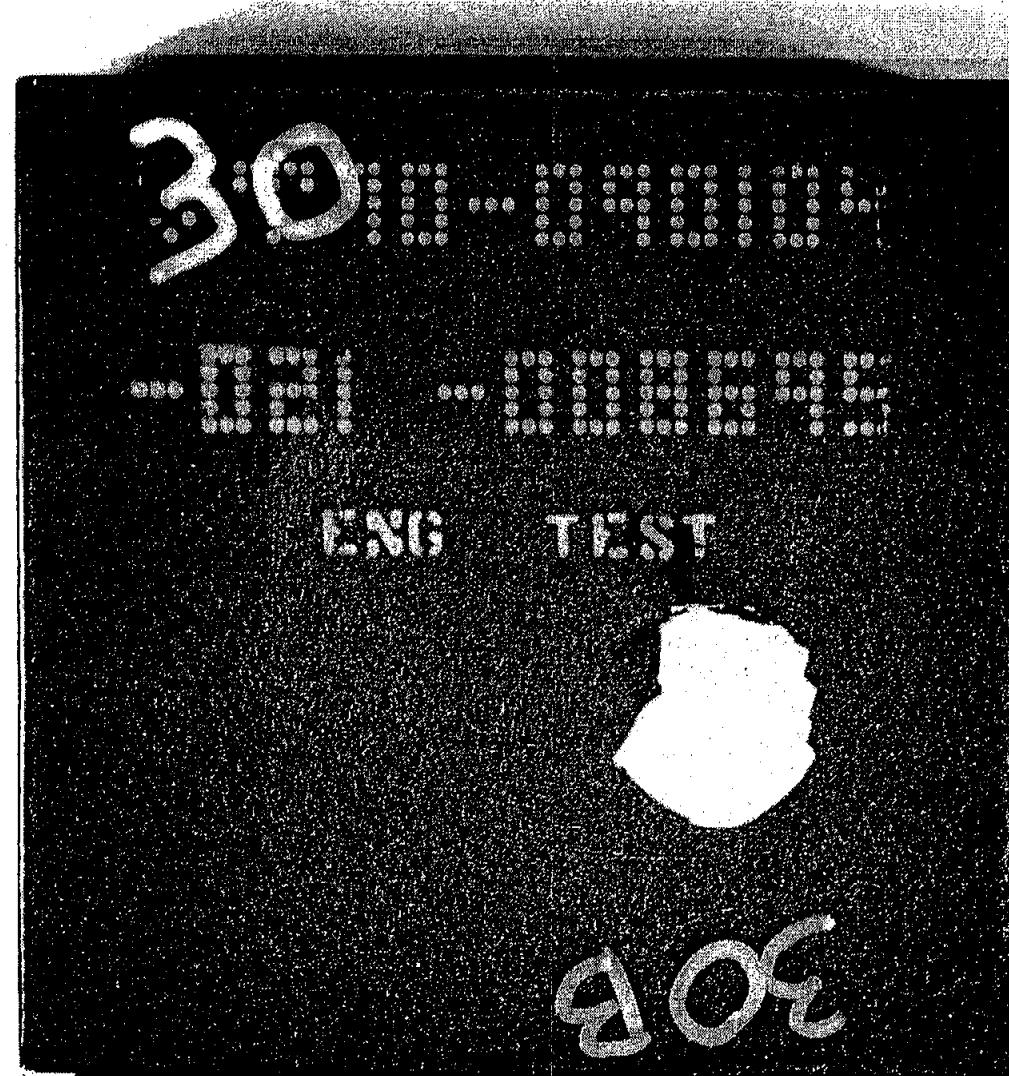
Tests No. 24D, 24E, and 24F



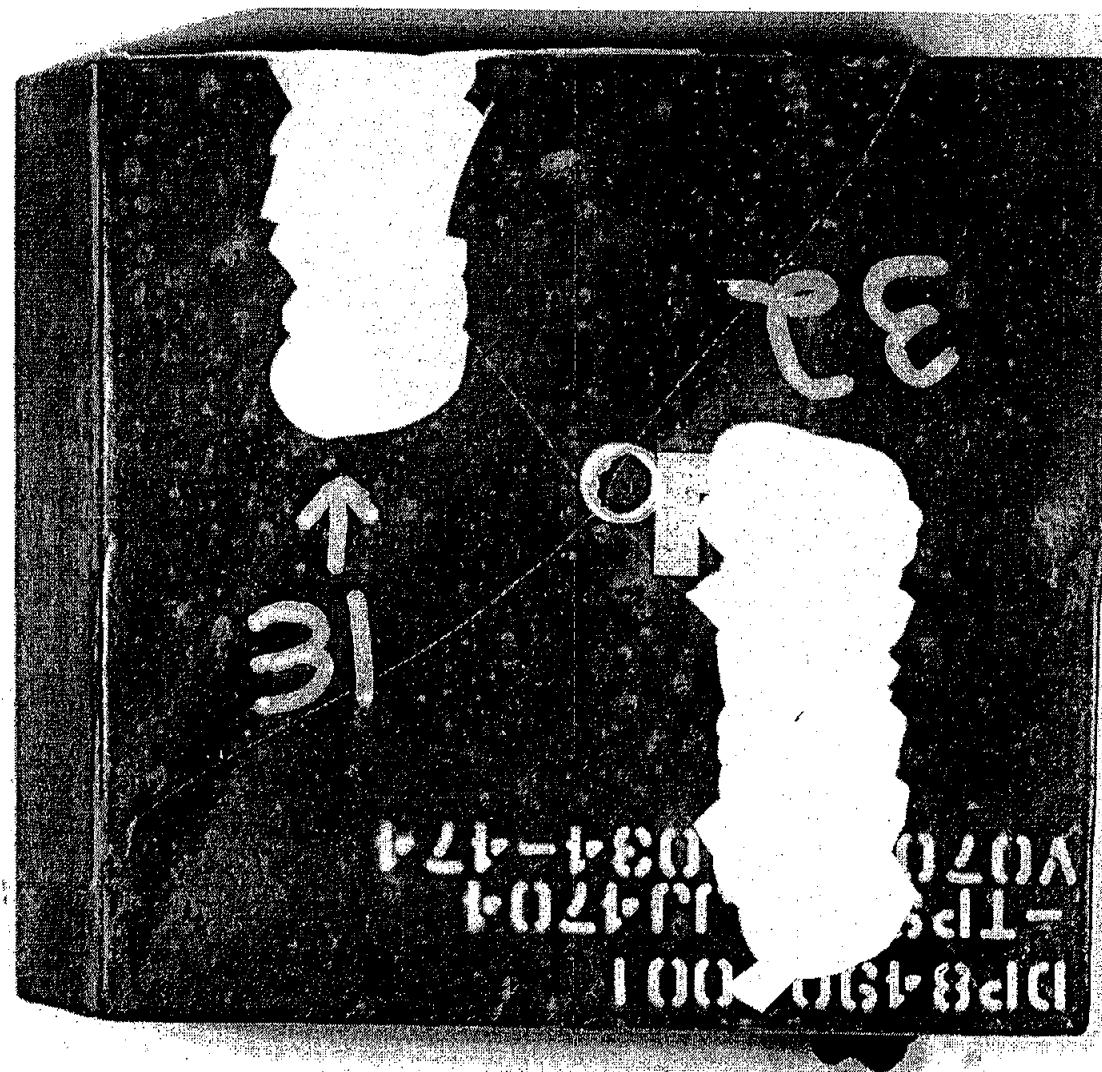
Tests No. 26 and 27



Tests No. 28A and 28B



Tests No. 30 and 30B



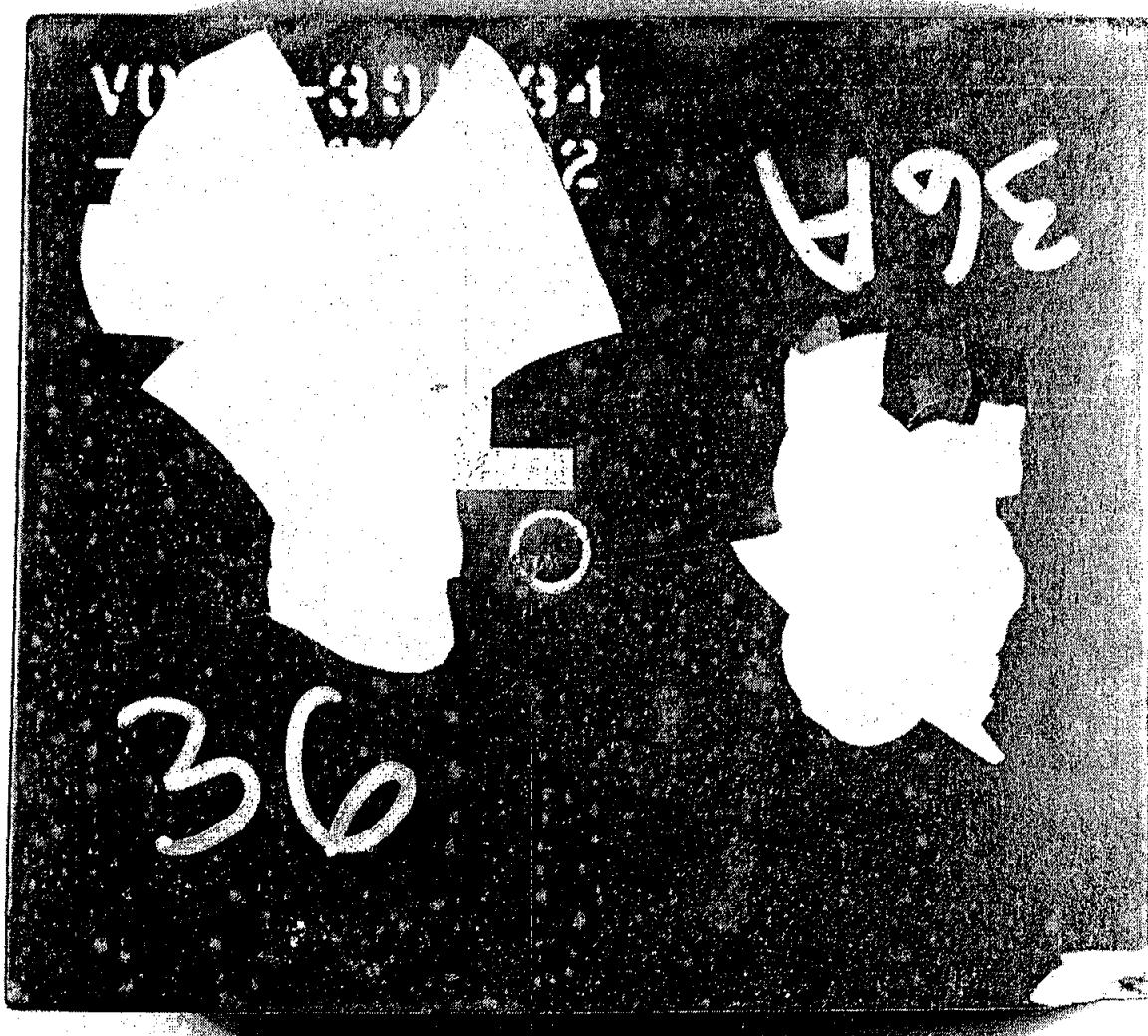
Tests No. 31 and 32



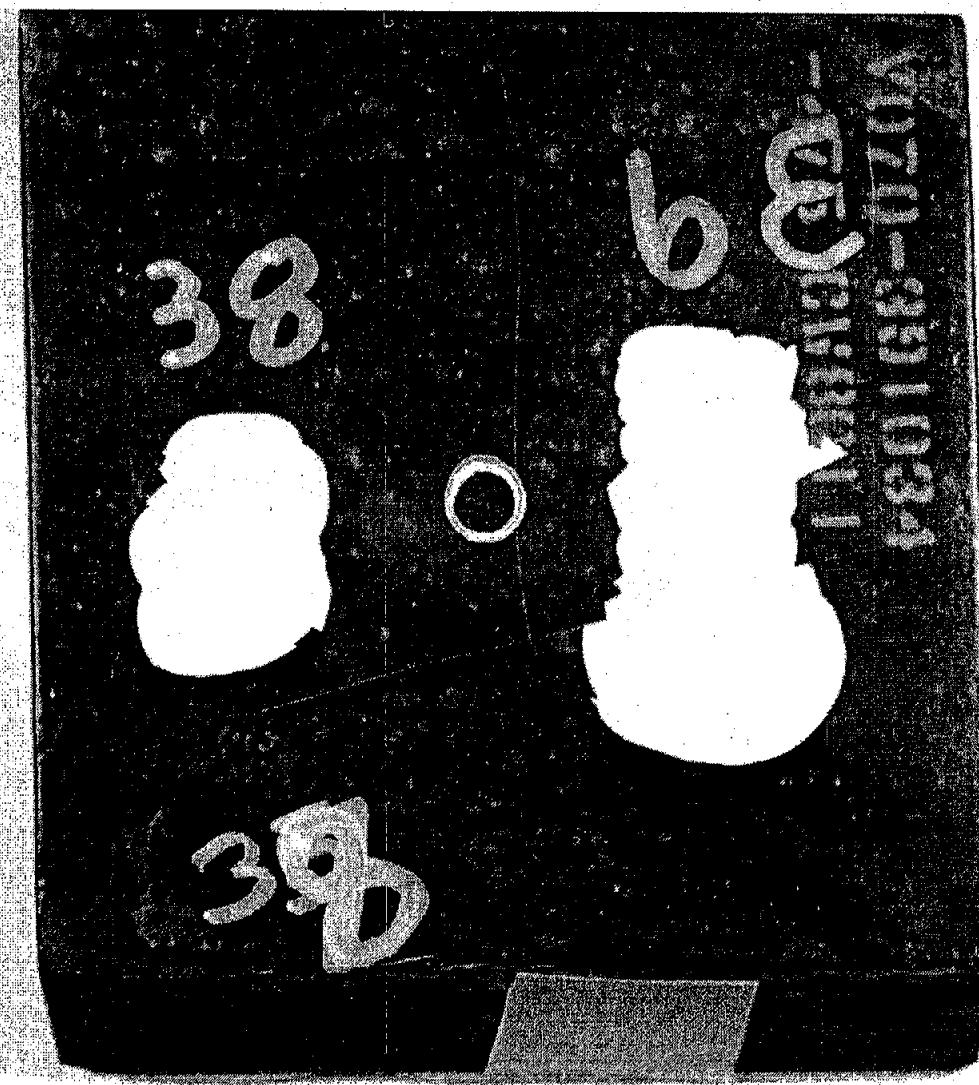
Test No. 34A



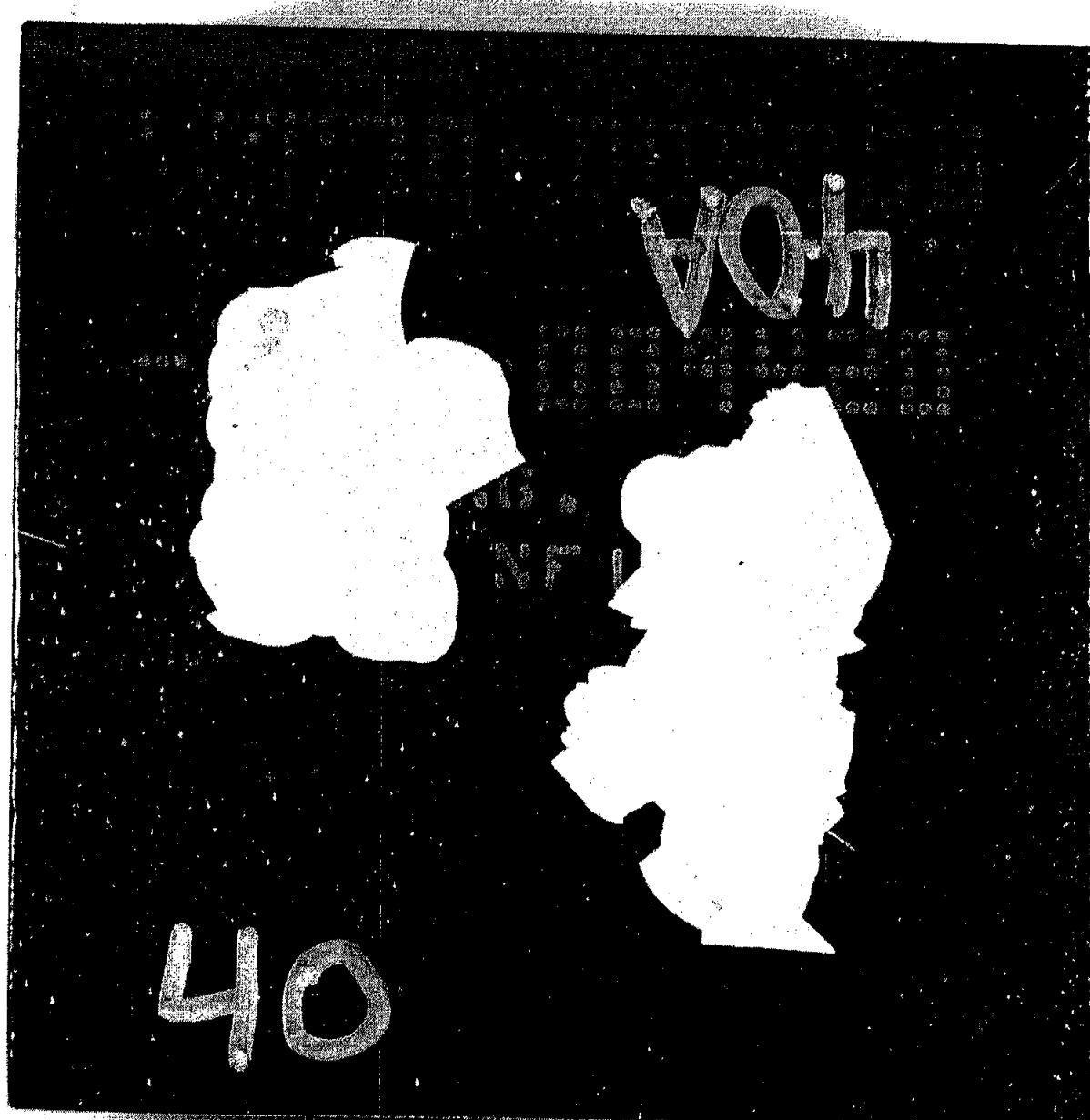
Tests No. 34 and 35



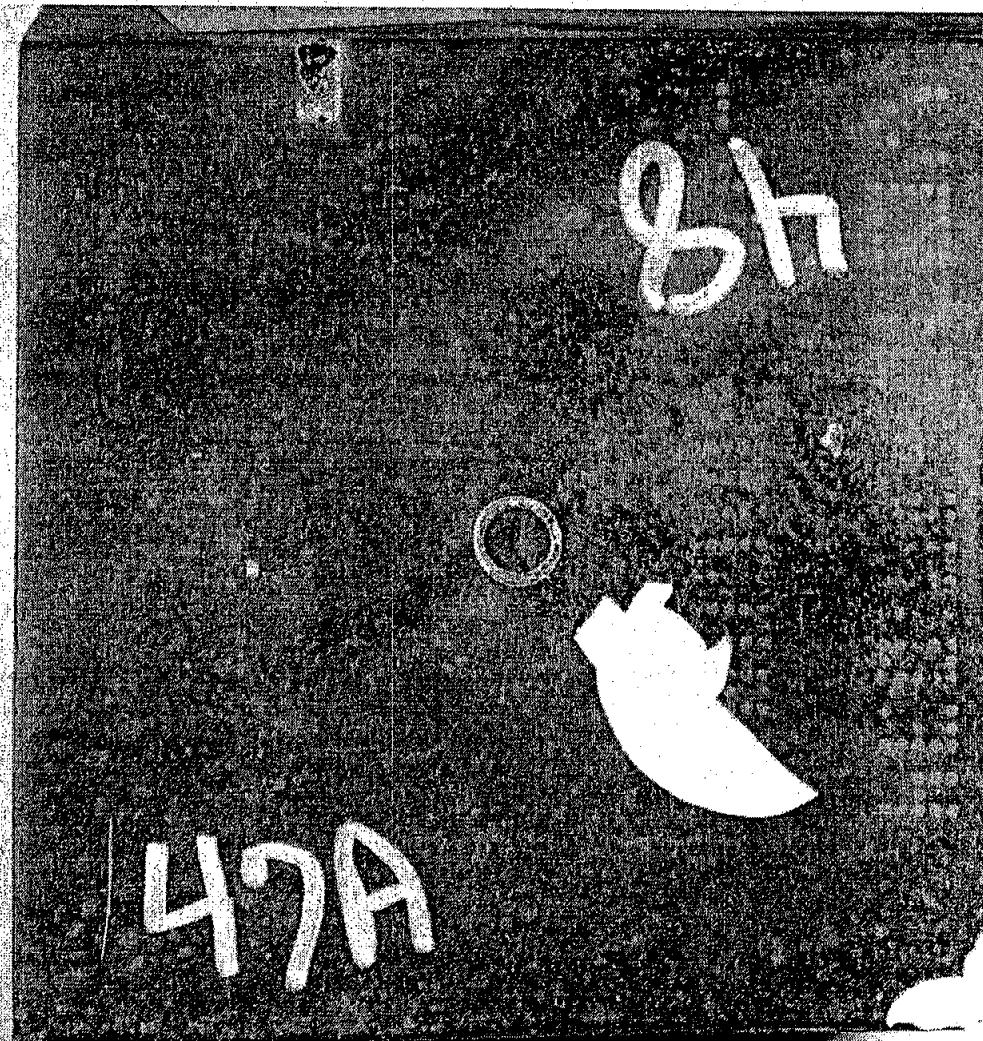
Tests No. 36 and 36A



Tests No. 38 and 39



Tests No. 40 and 40A



Tests No. 47A and 48



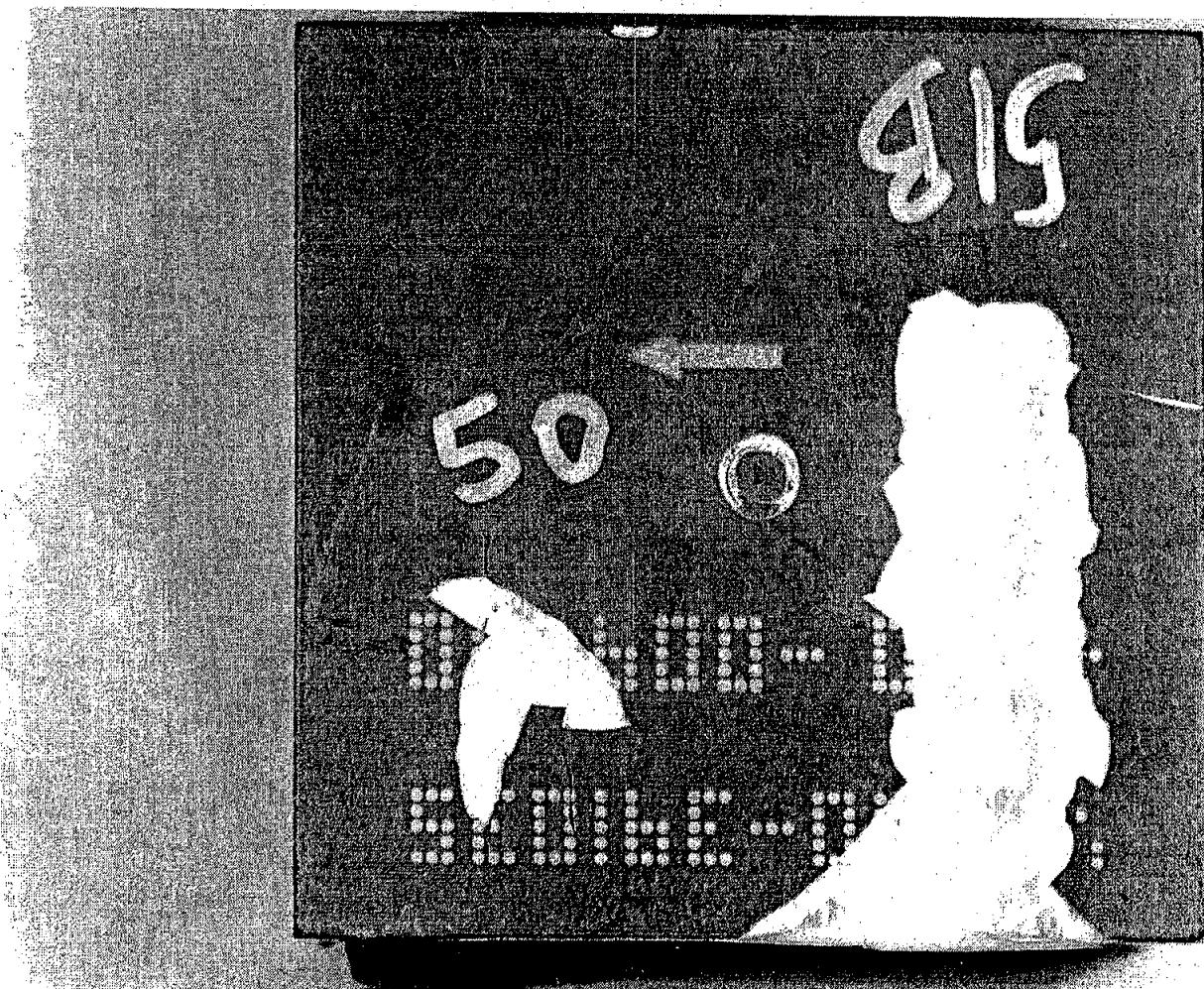
Tests No. 47 and 50A



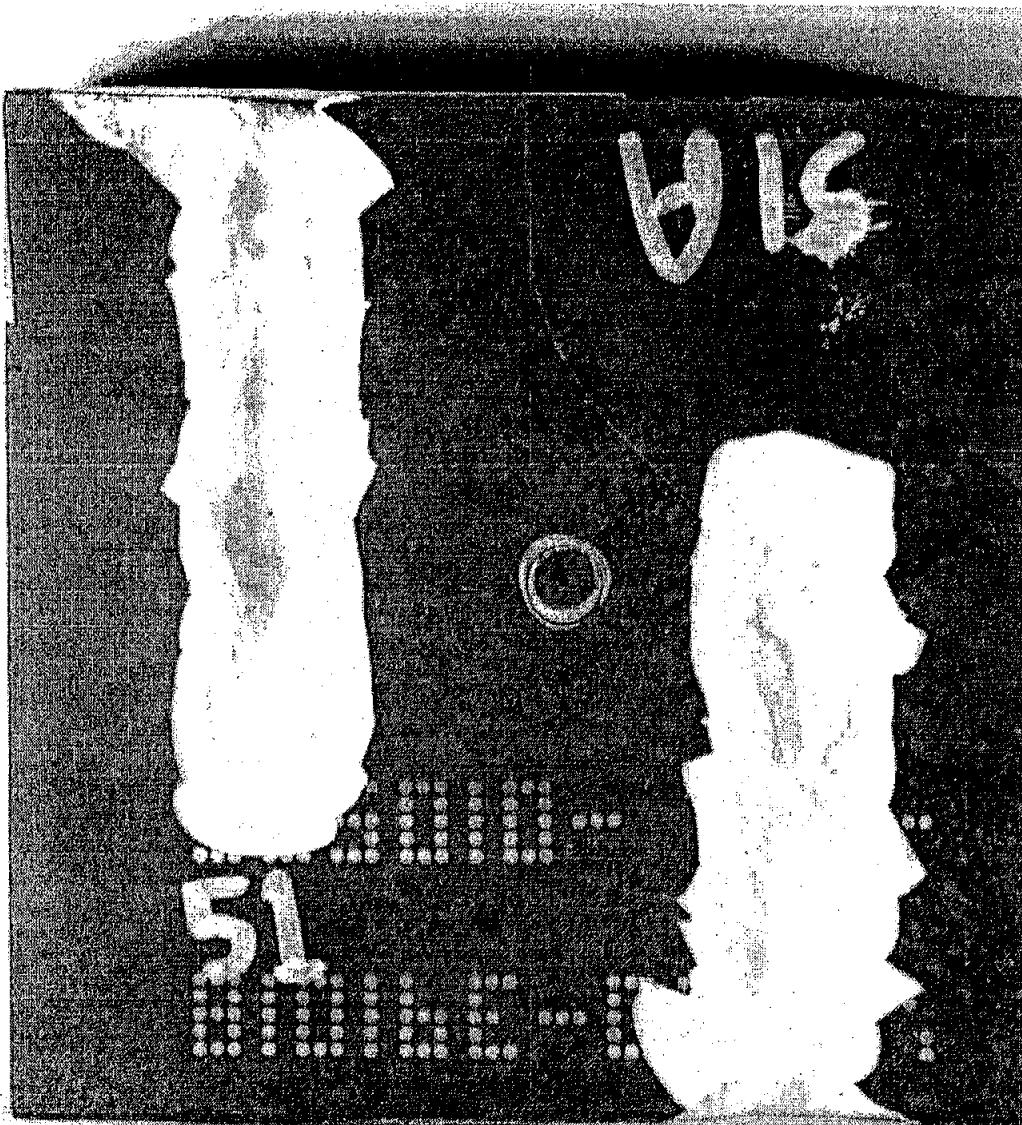
Test No. 48A



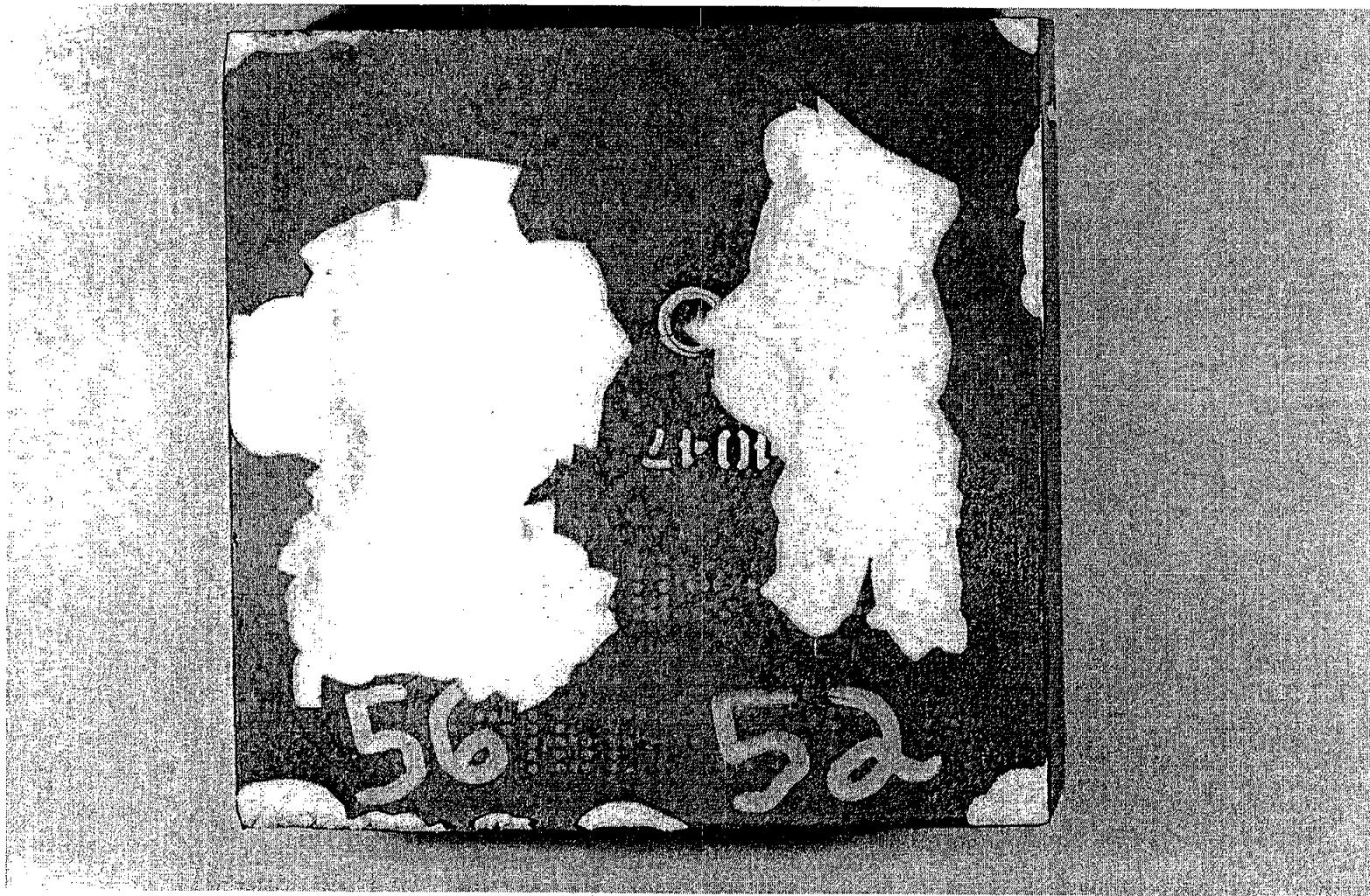
Tests No. 44 and 48C



Tests No. 50 and 51B



Tests No. 51 and 51A



Tests No. 52 and 56

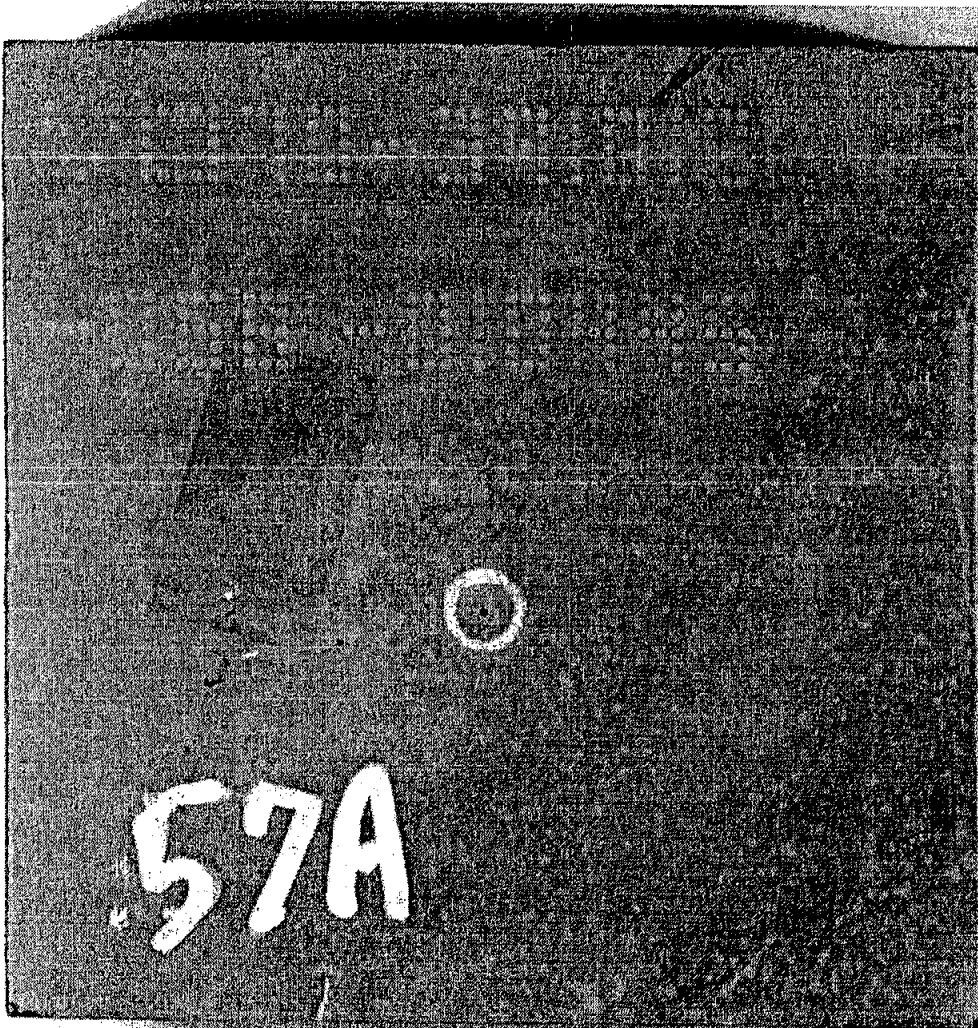


Tests No. 52A and 52B

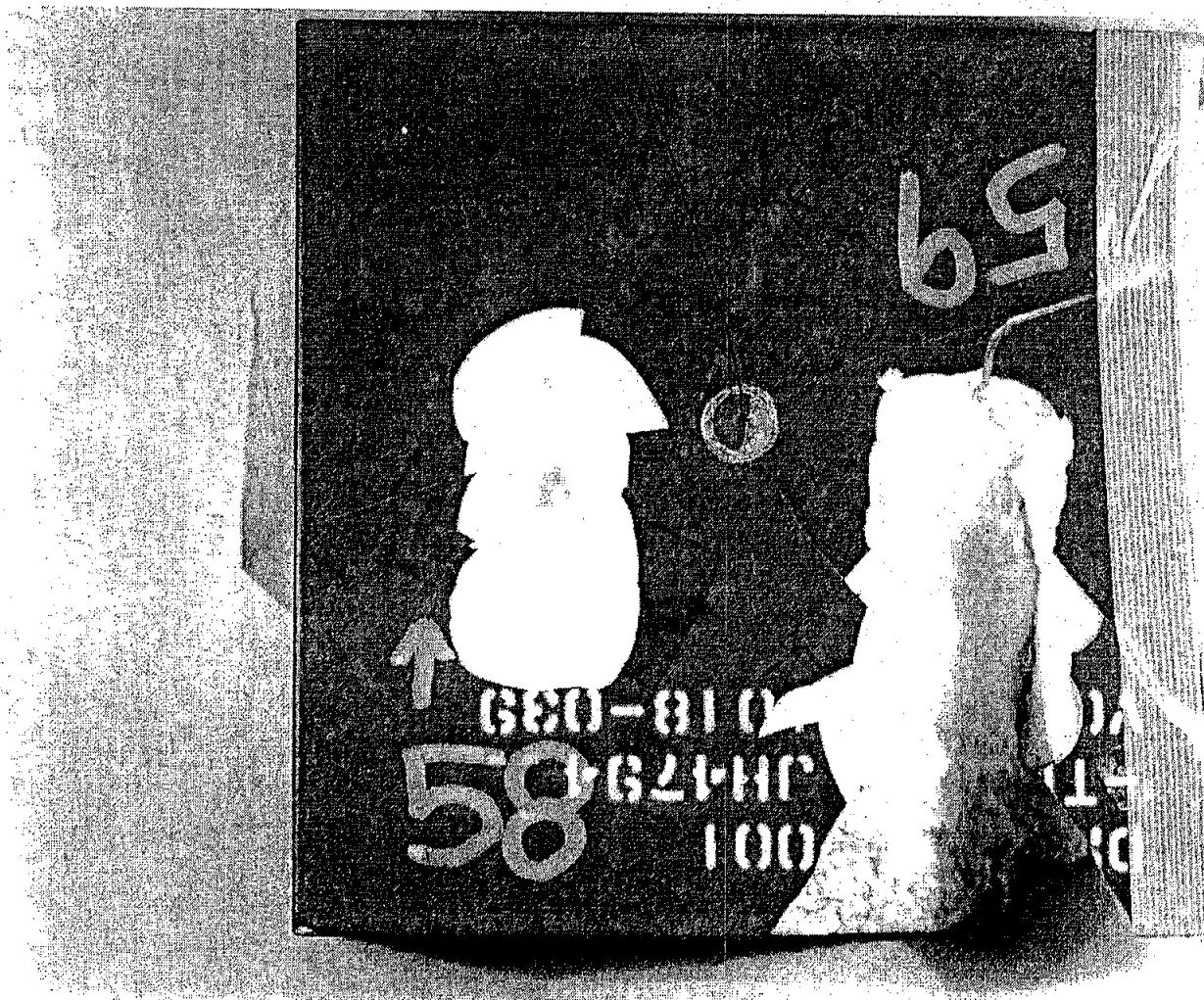
V070-391081  
-295 011025 55

54

Tests No. 54 and 55



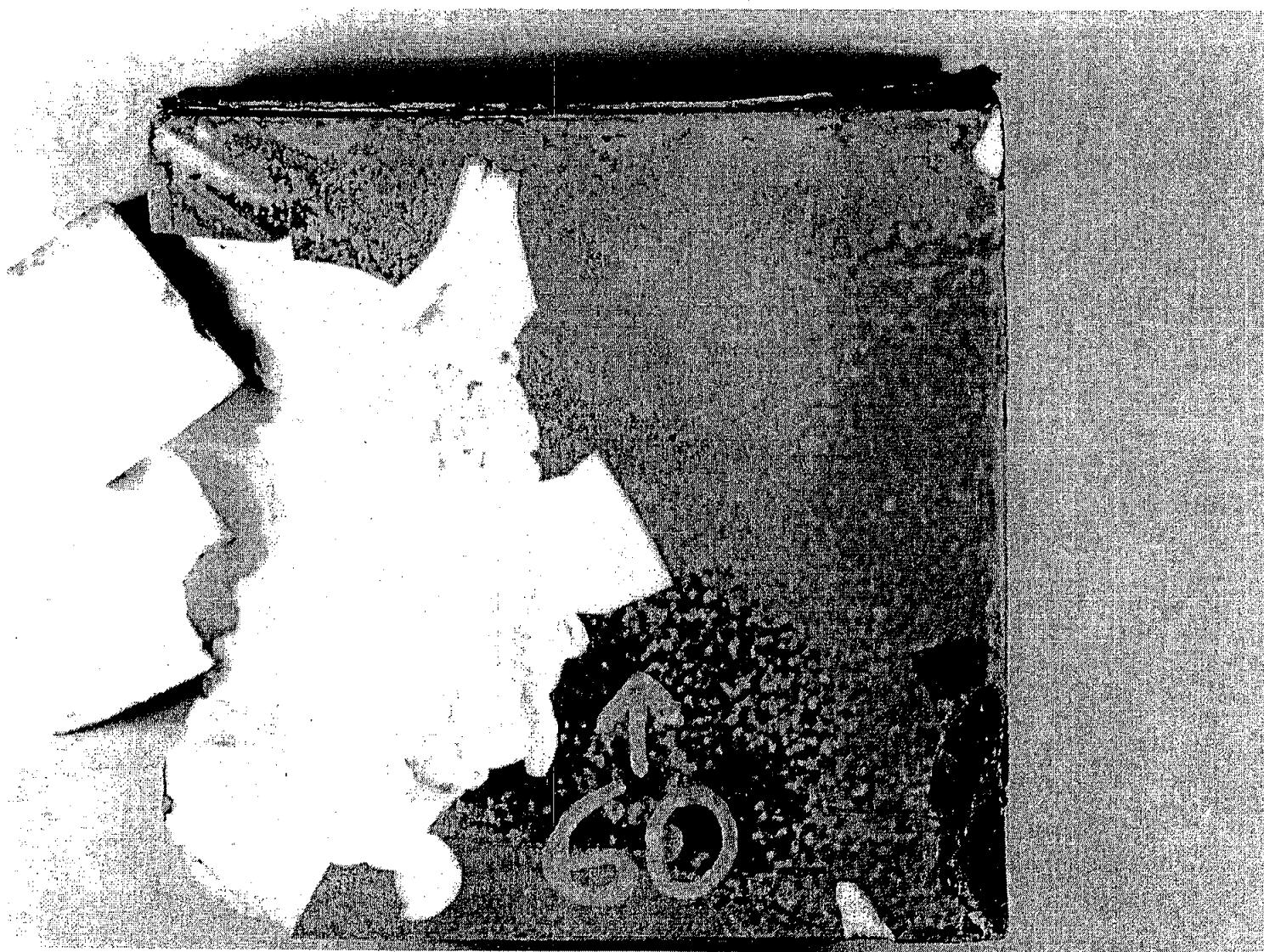
Test No. 57A



Tests No. 58 and 59



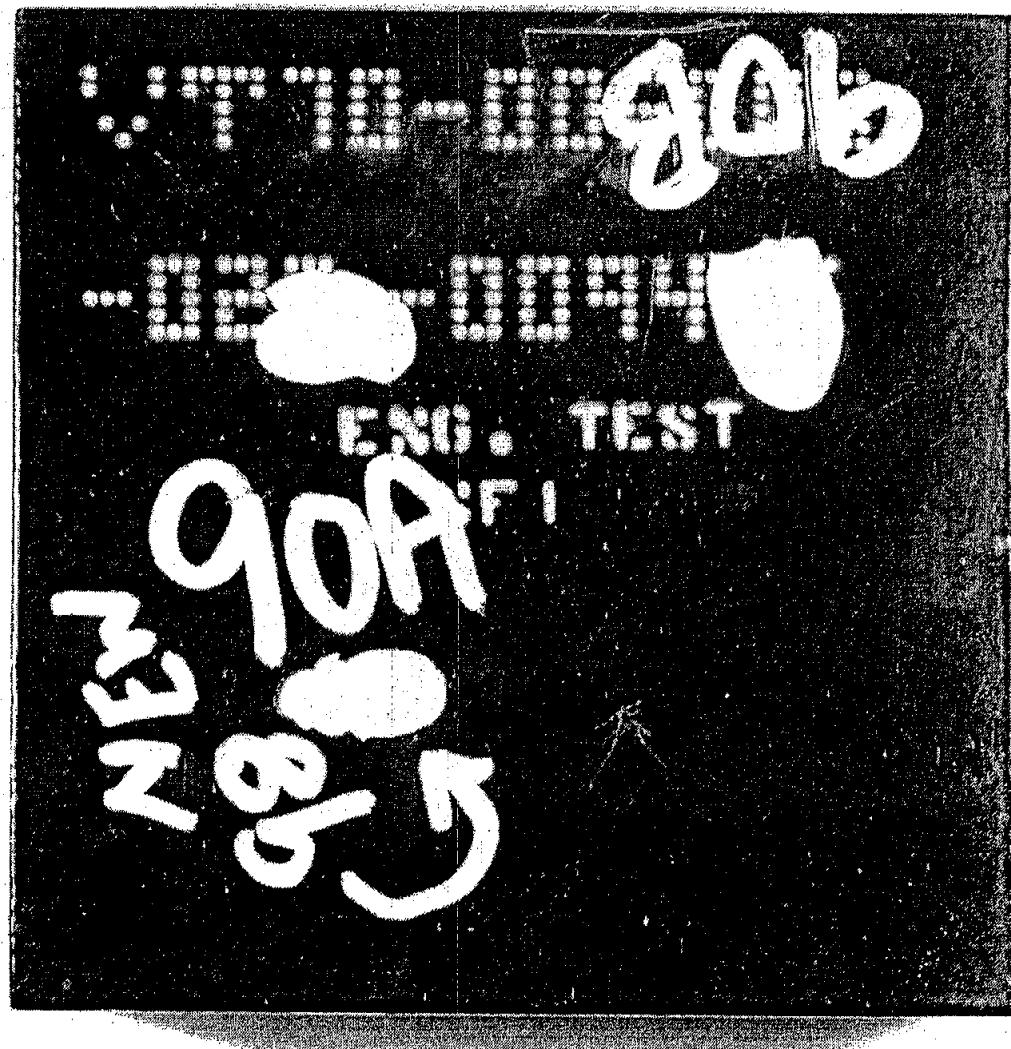
**Test No. 59A**



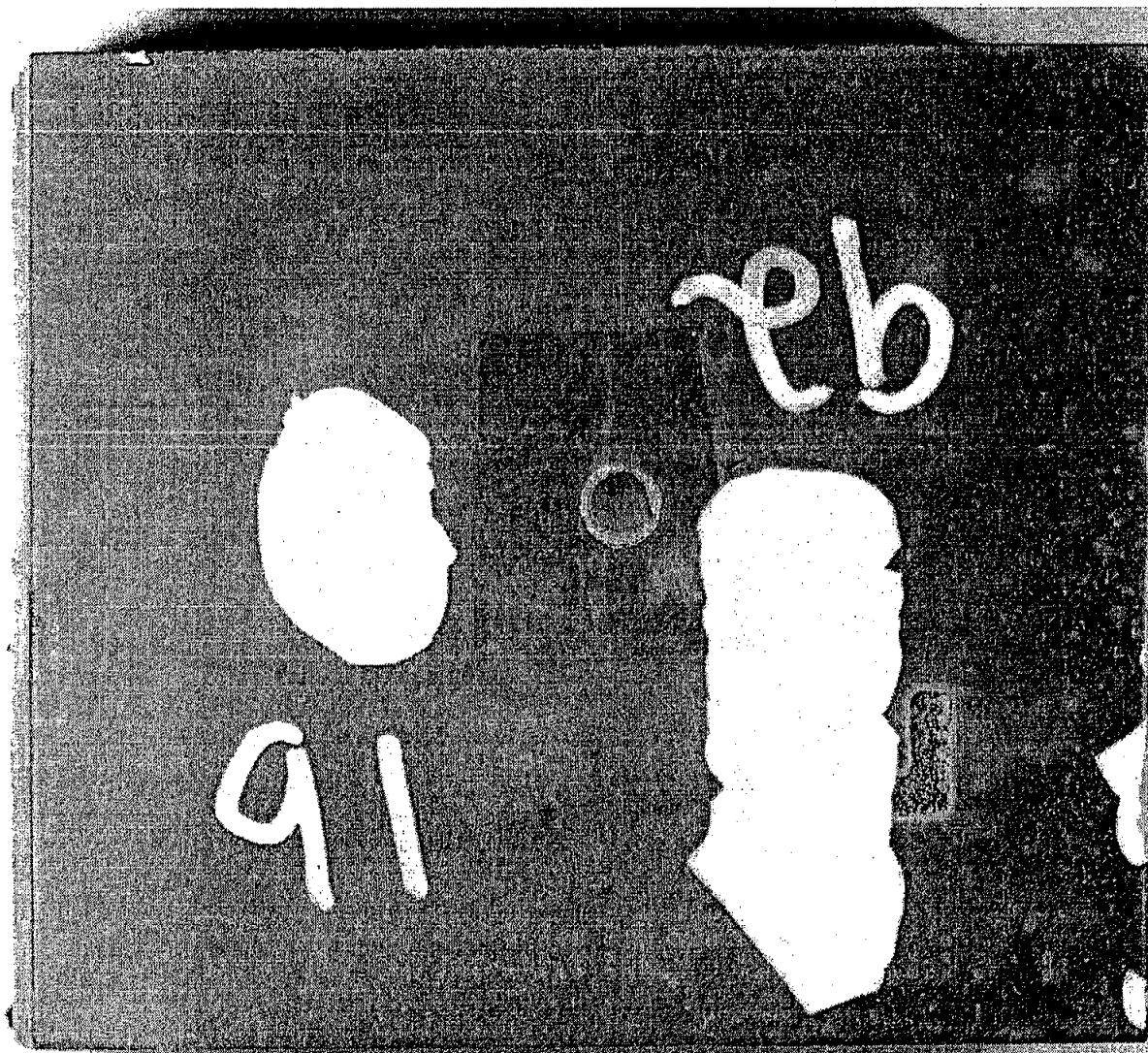
**Test No. 60**



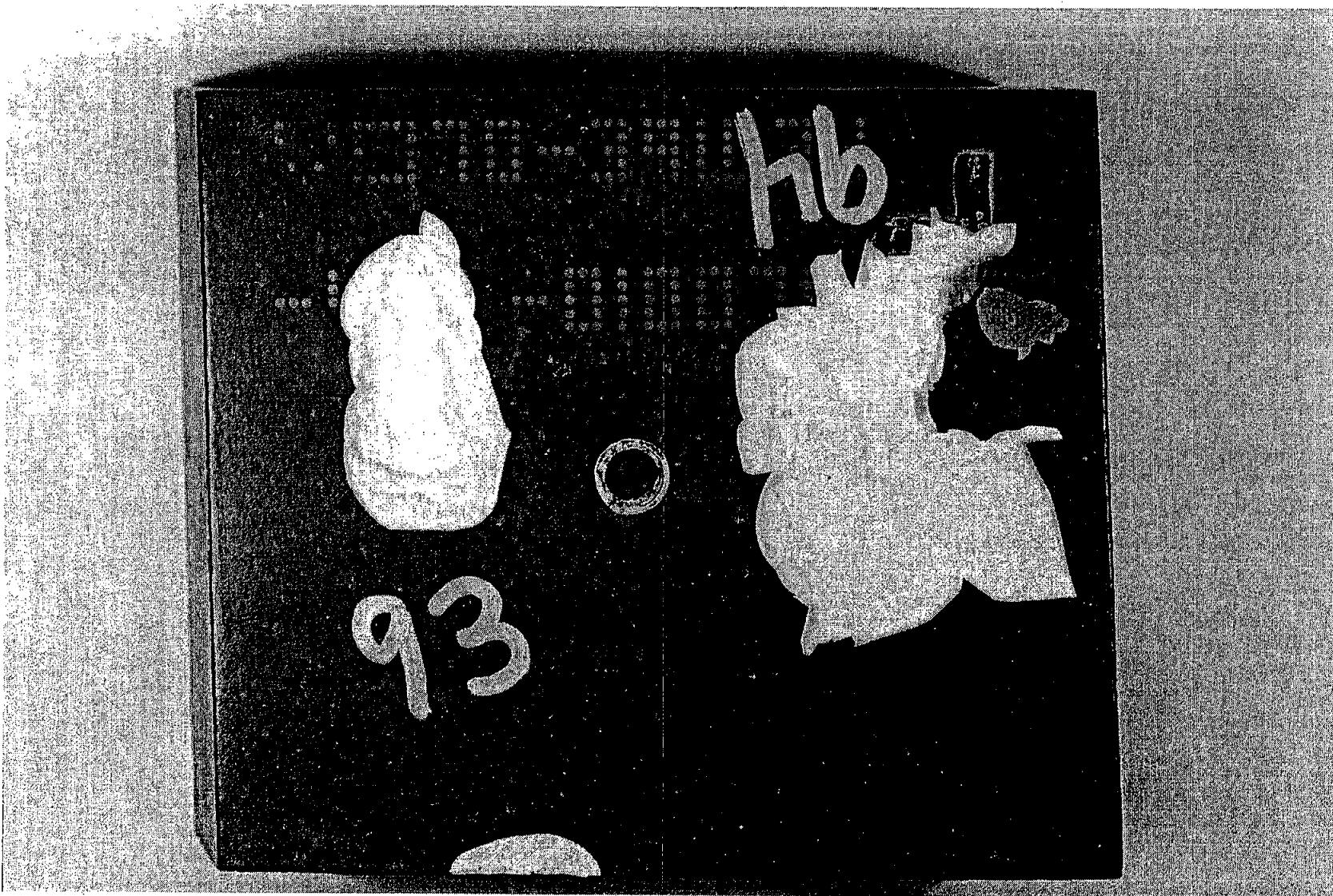
Tests No. 84B and 86



Tests No. 90A, 90B, and 98



Tests No. 91 and 92



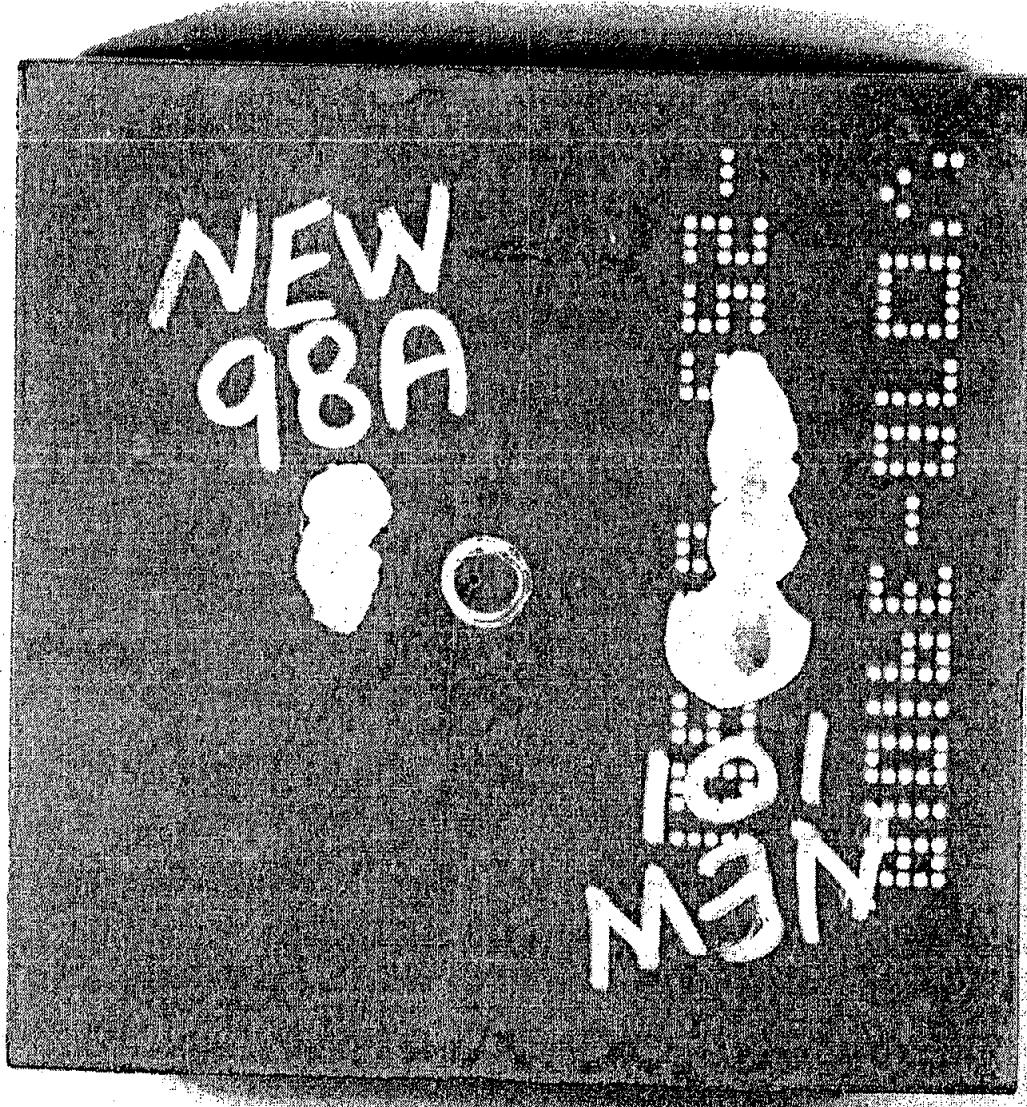
Tests No. 93 and 94



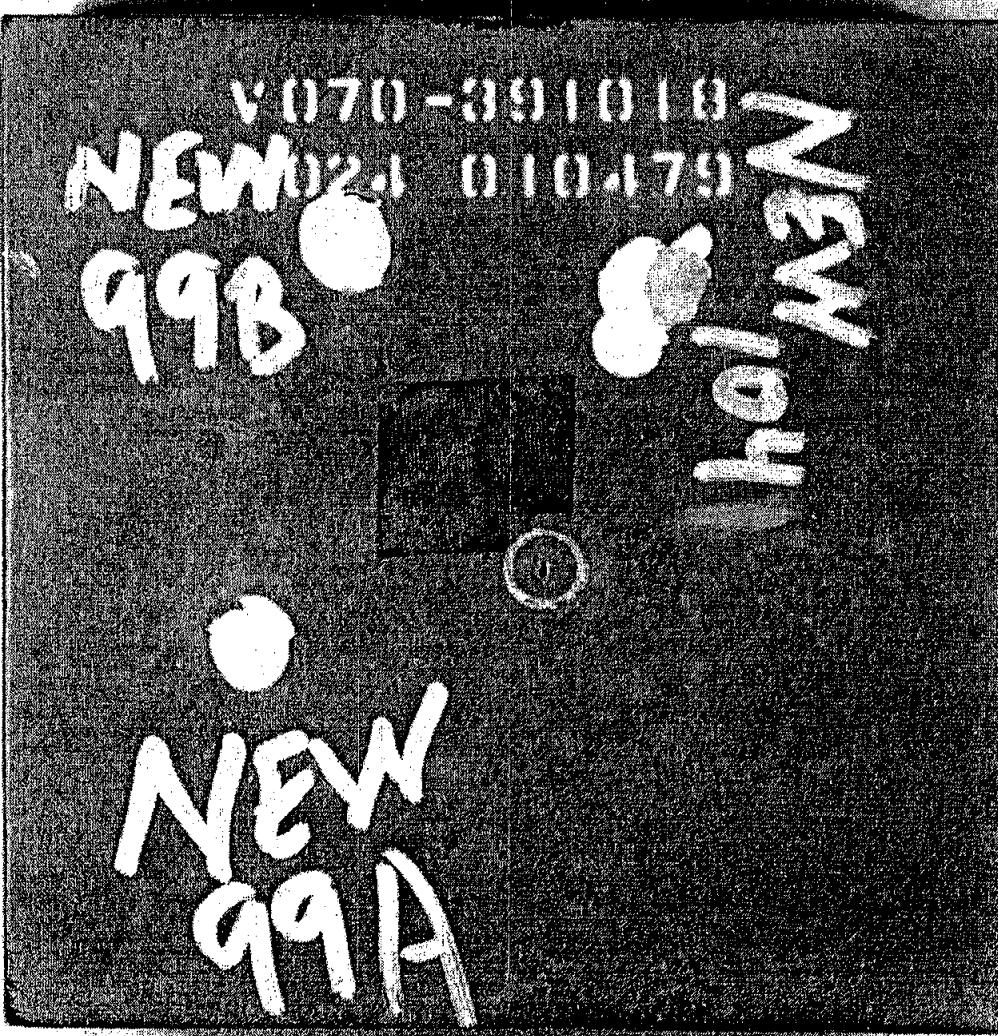
Test 94A



Tests No. 97 and 99



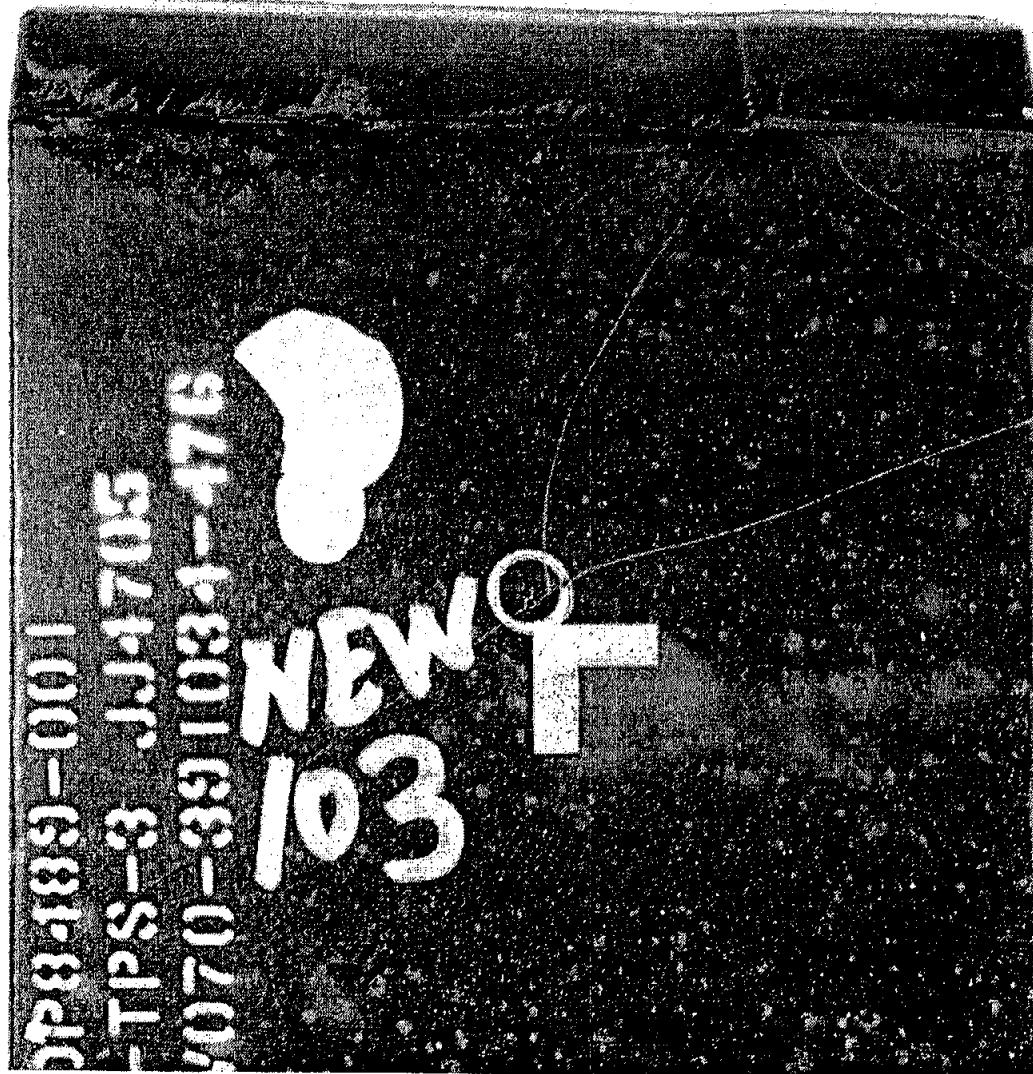
Tests No. 98A and 101



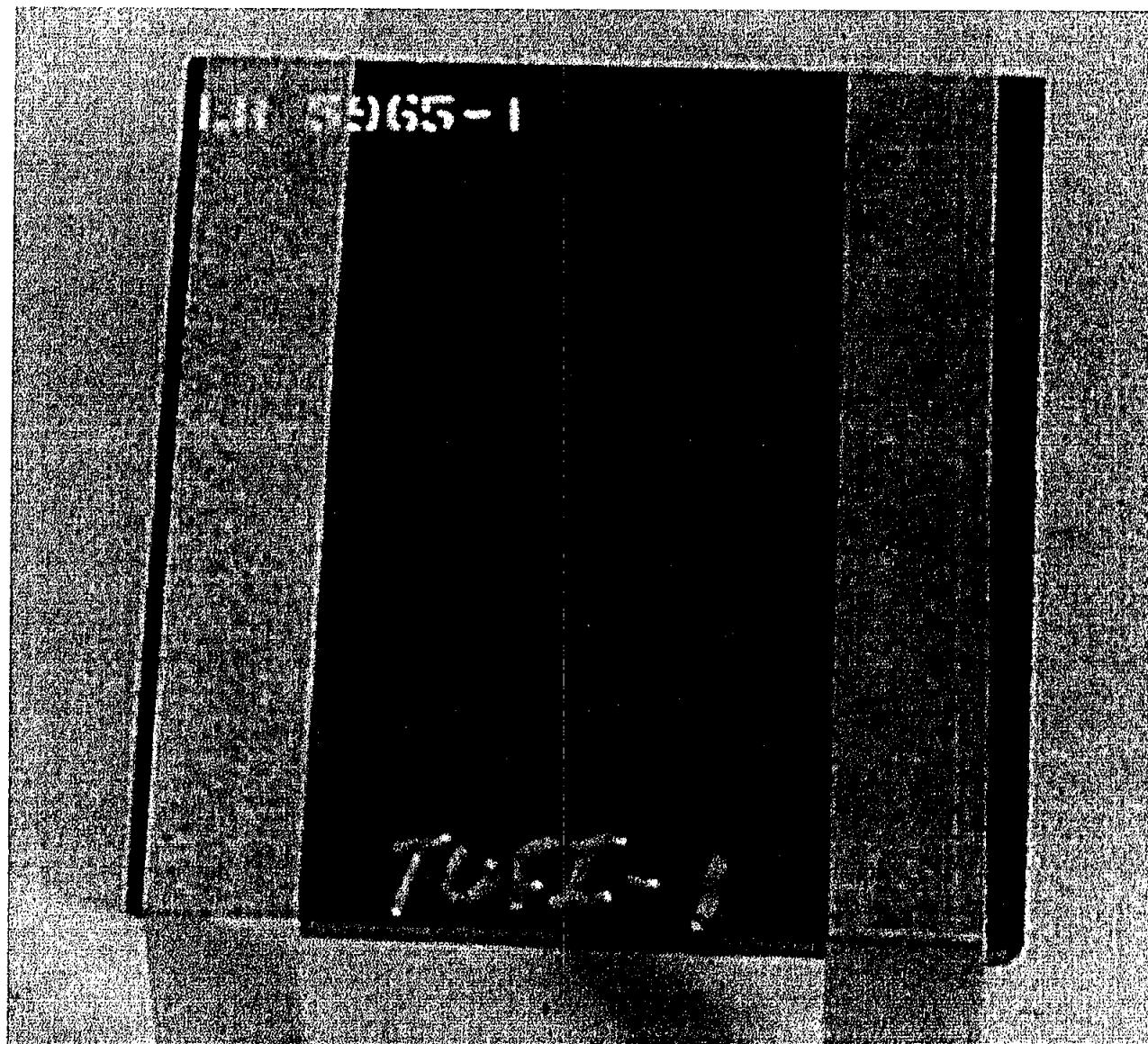
Tests No. 99A, 99B, and 104



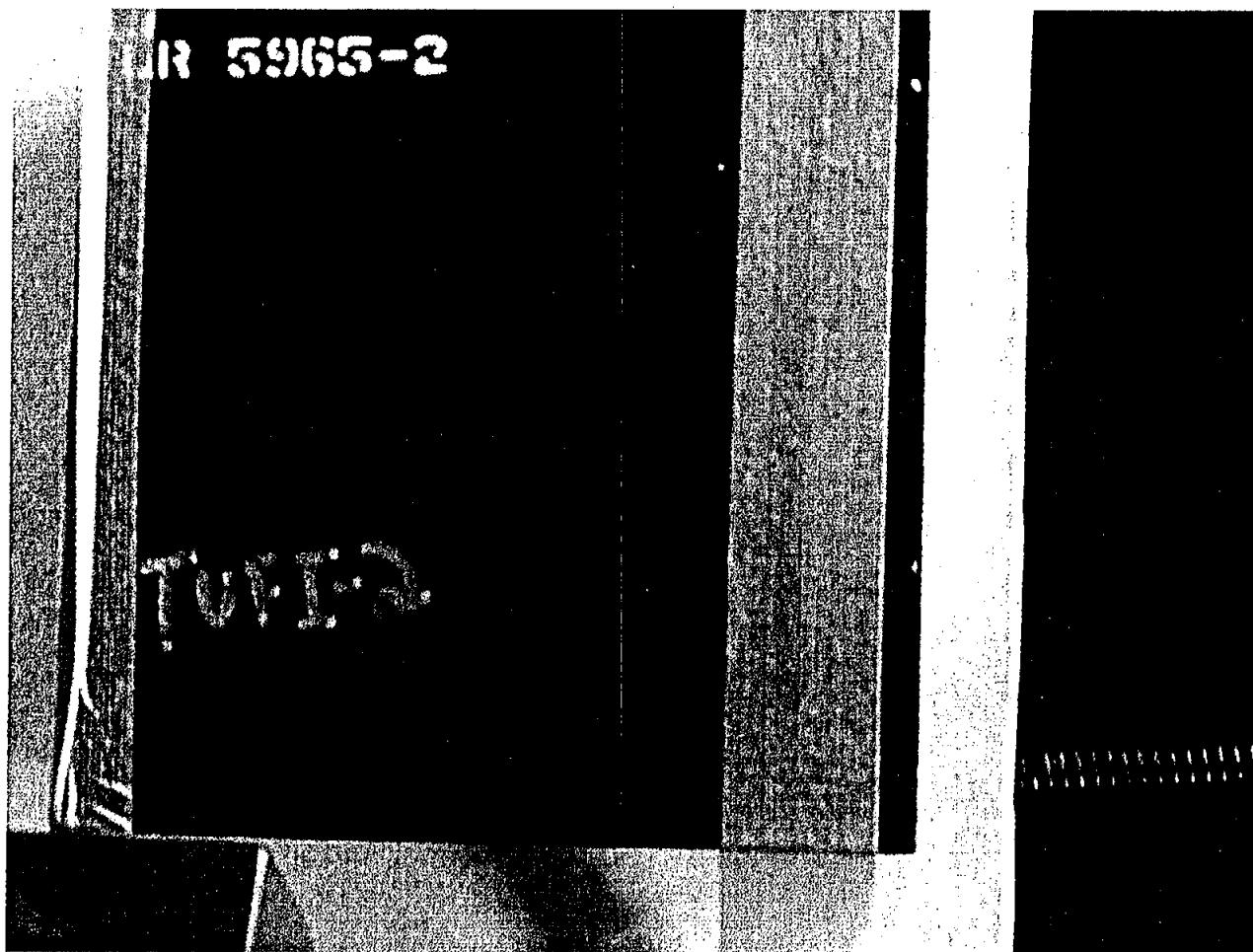
Tests No. 101A and 101B



Test No. 103



Test No. TUF-I-1



Test No. TUF-2

**APPENDIX B:**  
**DATA RECORD SHEETS**

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 1

Date: 12/28/98

Time: 2:20

Conditions: Sunny 66°F

Staff: DLG

Target Description:

Serial No. Fit Tile

Obliquity (deg.): 80°



Gun Pressure (psi): P1: 600, P2: 20, P3: 600

Velocity Measurement:

Measurement

1

2

Time (μs)

\_\_\_\_\_

\_\_\_\_\_

Velocity (fps)

\_\_\_\_\_

Ave.

441

Tile Damage Assessment:

Crater (Y/N): ○ Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- Same Fit Tile as Test #41 - Same Spot

- Good First Test - Good Velocity

- Projectile Flew Great & Bounced off Target

\* Note: Projectile Impacting on edge



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 2

Date: 12/28/98

Time: 2:35

Conditions: Sunny 70°

Staff: DLG

Target Description:

Serial No. F1T Tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: .89" X .89" X .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 40, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

975

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) Describe:

No Damage

Comments:

- Same F1T tile as Test #1 - same spot

- Good Test

- Projectile flew great

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 3

Date: 12/28/98

Time: 3:00

Conditions: Sunny 70°F

Staff: DLG

Target Description:

Serial No. F17 Tile  
Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"  
Projectile Weight (g): .11 g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 600, P3: 600

50

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>1166</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

No Damage

Comments:

- Same Tile as in Test #2 - same spot
- Good Test Good Velocity

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 4

Date: 12/28/98

Time: 3:30

Conditions: Sunny 72°F

Staff: DLG

Target Description:

Serial No. F17 Tile  
Obliquity (deg.): 80°



Gun Pressure (psi): P1: 600, P2: 600, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>1124</u>

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) Describe:

No Damage

Comments:

- same tile as Test 3 - same spot

- slow - reduce as 4A

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 4A

Date: 12/29/98

Time: 10:00

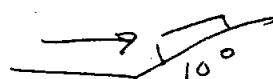
Conditions: Sunny 65°

Staff: SLG

Target Description:

Serial No. F1+714

Obliquity (deg.): 80



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 80, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1340

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

no damage

Comments:

Same tile as Test #4 same spot

Too slow - repeat as Test 4B

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 4B

Date: 12/24/98

Time: 10:40

Conditions: Sunny 68°

Staff: DLG

Target Description:

Serial No. FIT tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 100\*, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1550

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No damage

Comments:

- Same tile as 4A - same spot
- Good Test - Good Velocity (-50)
- Projectile flew great

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 5

Date: 12/29/98

Time: 11:30

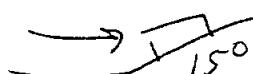
Conditions: Sunny 70° F

Staff: DG

Target Description:

Serial No. F17 tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 20, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

731

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- Save Tile as Test 6 - save spot  
- Too fast - OK

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 6

Date: 12/29/98

Time: 11:20

Conditions: Sunny 69°F

Staff: DLG

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

952

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

- No Damage

Comments:

-Same Tile as Test 9 - same spot

- Good Test - Vel. (+152 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 7

Date: 12/29/98

Time: 11:05

Conditions: Sunny 68° F

Staff: DLG

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1279

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

- No Damage

Comments:

- Same FIT tile as Test #8 - new spot

- Good Test - Velocity (+) 9 fps

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 8

Date: 12/29/98

Time: 10:45

Conditions: Sunny 68°

Staff: DLG

Target Description:

Serial No. F17-Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 100, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1606

Tile Damage Assessment:

Crater Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- Delamination of Coating 1.0" dia

- Some Coating has come off

Comments:

- Same F17 Tile as Test 4B - same spot

- Good Test - Good Velocity (+6 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 9

Date: 12/29/98

Time: 11:35

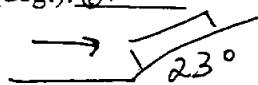
Conditions: Sunny 71°

Staff: DLG

Target Description:

Serial No. E11 Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 17, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

579

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) Describe:

No Damage

Comments:

- Same tile as Test 5 - same spot

- Good Test - high vel. (+179 ft/s)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 10

Date: 12/29/98

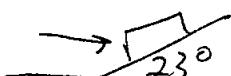
Time: 11:40

Conditions: Sunny 71°

Staff: DLG

Target Description:

Serial No. F17 T.4  
Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"  
Projectile Weight (g): .11g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 25, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>794</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

No Damage

Comments:

-Same Tile - Same Spot as Test 9

-Good Test - Good Velocity

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 11

Date: 12/29/98

Time: 11:10

Conditions: Sunny 73°F

Staff: DLG

Target Description:

Serial No. F17 tile

Oblliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 600, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1257</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

0.94" dia delamination of coating

Comments:

- Same tile as Test #9 - same spot

- Good test - Good Velocity (+57)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 12

Date: 12/30/98

Time: 10:00

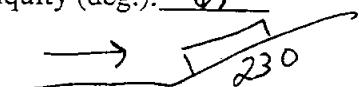
Conditions: Sunny 65°

Staff: DLG

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 100, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1490

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

1.25" dia Delamination of Coating

- Some Coating loss along edges of Delamination

Comments:

- Good Test - Good Velocity (- 110 fps) a little slow

Post-test Cracking

Air.   
Coating Missing

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 13

Date: 12/30/98

Time: 11:20

Conditions: Sunny 67°

Staff: DLG

Target Description:

Serial No. Eng tile  
Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"  
Projectile Weight (g): .11 g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 15, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>552</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

No Damage

Comments:

Same tile as Test 14 - same spot  
- Good Test, Velocity (+152 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 14

Date: 12/30/98

Time: 11:10

Conditions: Sunny 65°

Staff: DLG

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .114

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 25, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

825

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- No Damage

Comments:

- New Eng Tile    - Pre-test cracking    Aim Pt. 10  
- Good Test - Good Velocity (+25 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 15

Date: 12/30/98

Time: 10:45

Conditions: Sunny 67°

Staff: DLG.

Target Description:

Serial No. ENGR.Tile

Obliquity (deg.): 60



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_ guess 1200

Tile Damage Assessment:

Crater (Y/N): Length: .9 " Width: 1.1 " Depth: 0.12 "

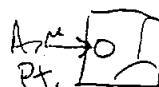
Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

Pre-test cracking



-Nontrigger - Pretrigger

\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 15A

Date: 12/30/98

Time: 11:00

Conditions: Sunny 67°

Staff: DLG

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1160

Tile Damage Assessment:

Crater (Y/N): Length: .94" Width: 1.25" Depth: .127"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

Same tile as Test #15 - New spot  
- Good Test - Good Velocity (~40 fps)

Pre-test cracking

A.M.

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 16

Date: 12/30/98

Time: 10:11

Conditions: Sunny 65°

Staff: DHG

Target Description:

Serial No. F15 Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: .89 X .89 X .25 "

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 00, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
	Ave. <u>—</u>	<u>guess 1500</u>

Tile Damage Assessment:

Crater (Y/N): Length: 0.9 Width: 1.10" Depth: 0.2"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

crack from crater

Comments:

- Same tile as Test #12 - New spot

- No Imageon - Pretrigger

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 16A

Date: 12/30/98

Time: 10:20

Conditions: Sunny 65°

Staff: DLC

Target Description:

Serial No. FIT tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 100, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess 1500

Tile Damage Assessment:

Crater (Y/N): Length: 1.2" Width: 1.2" Depth: 0.2"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

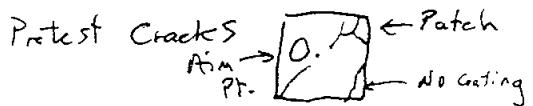
Tile Cracking (Y/N – Describe):

\_\_\_\_\_

\_\_\_\_\_

Comments:

- New FIT tile
- No Trigger



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 16B

Date: 12/30/98  
Time: 10:30  
Conditions: Sunny 66°  
Staff: DL/G

Target Description:

Serial No. FIT tile  
Obliquity (deg.): 60°  


Projectile Description:

Projectile Dimensions: .89" X .89" X .25"  
Projectile Weight (g): .11g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 100, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>1605</u>

Tile Damage Assessment:

Crater (Y/N): Length: 1.34" Width: 1.1" Depth: .26"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same tile as Test 16A - new spot
- Good test - Good Velocity
- Hit Aim!



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 17

Date: 12/30/98

Time: 1:35

Conditions: Partly Cloudy 68°

Staff: DLG

Target Description:

Serial No. Erg Tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 14, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

516

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- Same T.I.U as Test #13 - same spot  
- Good Test - Velocity (+116 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 18

Date: 12/30/98

Time: 1:40

Conditions: PC 68°

Staff: DLG

Target Description:

Serial No. Erg Tile  
Obliquity (deg.): 50



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"  
Projectile Weight (g): .116  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 25, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
	Ave.	<u>799</u>

Tile Damage Assessment:

Crater (Y/N): Length: .66" Width: .98" Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

.66 long x .98 wide dia. Delamination of Coating

Comments:

- same tile as Test #17 - same spot
- Good Test Good Velocity

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 19

Date: 12/30/98

Time: 2:00

Conditions: PL 68°F

Staff: JLG

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_ guess 1200

Tile Damage Assessment:

Crater (Y/N): Length: .8" Width: .11" Depth: .23"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- same tile as Test #18 - new spot  
- Pretrigger

\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 19A

Date: 12/30/98

Time: 2:15

Conditions: PC 68° F

Staff: DLG

Target Description:

Serial No. Erg Tile  
Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" X .89" X .25"  
Projectile Weight (g): .11 g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>885</u>

Tile Damage Assessment:

Crater (Y/N): Length: 0.9 " Width: 1.0 " Depth: 0.2 "

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

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Comments:

- Pretest cracking
- Too slow - Reduce

Aim Pt. →   
↓  
← chunks

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NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 19B

Date: 12/30/98

Time: 2:35

Conditions: PC 67°

Staff: DLG

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): ,11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

913

Tile Damage Assessment:

Crater (Y/N): Length: .8 " Width: 1.0 " Depth: .12 "

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Same Tile as Test #19A - New spot

- Too Slant

- Redup

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 19C

Date: 12/30/98

Time: 2:45

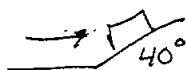
Conditions: Sunny 67°

Staff: DLC

Target Description:

Serial No. F14 Tile

Oblliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 70, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>453</u>

Tile Damage Assessment:

Crater (Y/N): Length: 1.0" Width: 1.2" Depth: .1"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

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Comments:

- Post test cracks
- Too Slow
- Projectile Rotated Up Slightly

Air pt.   
Patches

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NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 19D

Date: 12/30/98

Time: 3:00

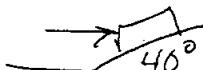
Conditions: sunny 68°

Staff: DLC

Target Description:

Serial No. F420000000000000000

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .1kg

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 80, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1252

Tile Damage Assessment:

Crater (Y/N): Length: 1.0" Width: 1.1" Depth: .41"

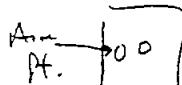
Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

~ Post test Cracking



~ Good Test - Good Velocity (+526 ft)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 20

Date: 12/30/98

Time: 3:05

Conditions: Sunny 68°

Staff: DLC

Target Description:

Serial No. Fmg Tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" X .89" X .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 100, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1120

Tile Damage Assessment:

Crater (Y/N): Length: 0.9" Width: 1.05" Depth: .35"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same tile as Test 19D - new spot

- Too Slow

\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 20A

Date: 12/30/98

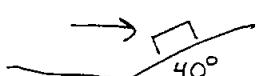
Time: 3:15

Conditions: Sunny 68°

Staff: DLC

Target Description:

Serial No. F1t tile  
Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" X .89" X .25"  
Projectile Weight (g): .11g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): 120

Gun Pressure (psi): P1: 600, P2: 600, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>— gun S5 1500</u>

Tile Damage Assessment:

Crater (Y/N): Length: 1.0" Width: 1.4" Depth: 0.4"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

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Comments:

Post test cracks A.M. Pt.

- No Impact

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NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 20B

Date: 12/30/98

Time: 3:30

Conditions: Sunny 68°

Staff: DLG

Target Description:

Serial No. F17 tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .116

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 120, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

1074

Tile Damage Assessment:

Crater (Y/N): Length: 1.0 Width: 1.2" Depth: .28"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

Same tile as Test 20A - new spot  
Too slow

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 20C

Date: 12/30/98

Time: 3:45

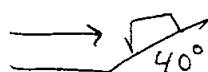
Conditions: Sunny 68°

Staff: DLG

Target Description:

Serial No. FIT TILE

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): 41g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

Slow 1250

Tile Damage Assessment:

Crater (Y/N): Length: .94 Width: .11" Depth: .30

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

Comments:

Pretest Cracking   
- No Fracture

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 201D

Date: 12/31/98

Time: 9:25

Conditions: Cloudy 62°

Staff: DLG

Target Description:

Serial No. F17 tile

Obliquity (deg.): 50



Projectile Description:

Projectile Dimensions: .89" X .89" X .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 100, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1081

Tile Damage Assessment:

Crater (Y/N): Length: 1.0" Width: 1.2" Depth: .25"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Comments:

- Some Tile or Test 20C - New Spot

- Too Slow

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 20E

Date: 12/31/98

Time: 9:35

Conditions: Cloudy 62°

Staff: DG

Target Description:

Serial No. F11 tile

Obliquity (deg.): 50°



Gun Pressure (psi): P1: 600, P2: 600, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess 1500

Tile Damage Assessment:

Crater (Y/N): Length: 1.1" Width: 1.2" Depth: .50"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- 
- 
- 
- Comments:
- Pretest Cracking Apt. R.O.
  - No Inacon
- 
- 
-

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 20 F

Date: 12/31/98

Time: 9:45

Conditions: Cloudy 62°

Staff: DLC

Target Description:

Serial No. F14 tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): 114

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

1520

Tile Damage Assessment:

Crater (Y/N): Length: 1.44" Width: 1.2" Depth: .47"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same Tile as Test 20E - New Spot
- Good Test - Good Velocity & (-80 f/s)

Post-test cracking

AM Pt. 15

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 21

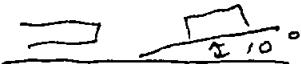
Date: 12/10/98

Time: 9:45

Conditions: Cloudy 50°F

Staff: \_\_\_\_\_

Target Description:

FIT  
Serial No. ~~200~~ T. Le  
Obliquity (deg.): 80  


Projectile Description:

Projectile Dimensions: 1" x 1" x 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 19, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.		<u>338</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- FIT Tile
- Intended Velocity 400 (- 62 fps)
- No Damage

Impact  Pre-test cracks

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 22

Date: 12/10/98

Time: 10:00

Conditions: Cloudy 50°

Staff: \_\_\_\_\_

Target Description:

Serial No. F4 Tile  
Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1" x 1" x 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 30, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>670</u>

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Some Tile as test 21
- Intended velocity 800 fps (-130)
- NO Damage

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 23

Date: 12/10/98

Time: 10:20

Conditions: Cloudy

Staff: \_\_\_\_\_

Target Description:

Serial No. FIT TILE

Obliquity (deg.): 80

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 50, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1147

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- Small Crack formed - extending from  
water proofing hole (RGG only)

5

Comments:

- Same tile as Test 22

- Intended Velocity 1200 (- 53 fps)

- No Damage

- Good shot

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 24 E

Date: 12/10/98

Time: 11:50

Conditions: \_\_\_\_\_

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 80°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 175, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess  $\approx$  1400

Tile Damage Assessment:

Crater (Y/N): Length: too shallow to measure Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Coating Damage 3.0" Long x 1.5" wide

Comments:

-Same Tile as 24 D

-No Velocity

-Pretriggered

-No Incon Image

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 24F

Date: 12/10/98

Time: 1:00

Conditions: Rainy 50°F

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64..

Gun Pressure (psi): P1: 600, P2: 175, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1788

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

RCG delamination 2.0" X 2.5"

Comments:

AS 24E

- Sore tile - rotated to rear spot
- Good test
- Slightly Higher Velocity

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 24

Date: 12/10/98

Time: 11:00

Conditions: Cloudy 50°F

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 80°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 90, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1108</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

RCC Delamination

Comments:

- Same tile as Test 23

- Intended Velocity 1600 (-492 ft)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 24B

Date: 12/10/98

Time: 11:10

Conditions: \_\_\_\_\_

Staff: \_\_\_\_\_

Target Description:

Serial No. F11 Tile

Obliquity (deg.): 80°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

150

Gun Pressure (psi): P1: 600, P2: 1000, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1317</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- RCBG damaged

Comments:

- Intended Velocity 1600 fps (-283 fps)
- Note that Pretest Photo was labelled #25 instead of 24B

Posttest Cracks  
X Impact

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 24 C

Date: 12/10/98

Time: 11:30

Conditions: Cloudy 50°F

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 80°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 220, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1548

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

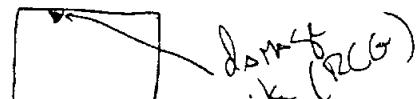
Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

R C B G - small area damaged

Comments:

- Intended Velocity 1600 fps *(Good Vel. leading Particles)*
- New Tile
- Projectile Broke up



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 24D

Date: 12/10/98

Time: 11:45

Conditions: 50°F

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng T. 4

Obliquity (deg.): 80

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 200, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

R C G Damage extended to  
1.5" Length 

Comments:

- Same tile as 24C
- No Velocity
- Projectile Broke up into Pieces
- No Inacon file

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 25

Date: 12/10/98

Time: 2:15

Conditions: Rainy 50°

Staff: \_\_\_\_\_

Target Description:

Serial No. E5 Tile

Obliquity (deg.): 75°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 18, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

490

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same Tile as 26A - same spot

- Intended Vel. (400 Fps) +90

- Good Shot

- No Damage

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 26

Date: 12/10/98

Time: 1:55

Conditions: Rainy 50°F

Staff: \_\_\_\_\_

Target Description:

Serial No. F1+ Tile

Obliquity (deg.): 75°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): 64

Gun Pressure (psi): P1: 600, P2: 40, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.	_____	guess <u>800fps</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

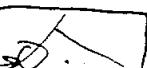
→ Delamination 1.25" dia

No Coating Loss

Comments:

- Same F1+ tile different spot
- Intended Velocity 800fps
- No velocity
- No impact

Post test cracking

Impact 

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 26A

Date: 12/10/98

Time: 2:10

Conditions: \_\_\_\_\_

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 75°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 40, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

856 fps

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Good Test

- No Damage

-

\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 27

Date: 12/10/98

Time: 1:40

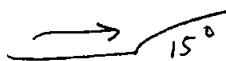
Conditions: Rainy 50° F

Staff: \_\_\_\_\_

Target Description:

Serial No. Fit Tile

Obliquity (deg.): 25°



Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): 64

Gun Pressure (psi): P1: 600, P2: 90, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1221

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Coating Delamination 1.25" x 2.5"

Comments:

- Good test, vel.

Post-test Cracks



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 28

Date: 12/10/98

Time: \_\_\_\_\_

Conditions: \_\_\_\_\_

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 75



Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): 64

Gun Pressure (psi): P1: 600, P2: 175, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

Tile Damage Assessment:

Crater ~~(Y/N)~~: Length: \_\_\_\_\_ Width: \_\_\_\_\_

Velocity of Particle 1556 fps  
Particle Size: .41" x .20" x .39"

Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking ~~(Y/N - Describe):~~

Star Crack

X at impact

Comments:

- Intended Vel of (1600 fps)

- Projectile Broke up

- Reduce

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 28A

Date: 12/10/98

Time: \_\_\_\_\_

Conditions: cloudy 50°

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng tile

Obliquity (deg.): 75°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 175, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1365

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Delamination of Coating 1.0" X 3.0"

Comments:

- Same Tile - Same spot
- Good test

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 28B

Date: 12/10/98

Time: 1:30

Conditions: \_\_\_\_\_

Staff: \_\_\_\_\_

Target Description:

Serial No. Erg Tile

Obliquity (deg.): 25°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .64

Gun Pressure (psi): P1: 600, P2: 190, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1465</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Coating Delamination 2.0" X 2.0"

Comments:

- Same tile as 28A - Different spot

- Good test - Projectile broke into multiple pieces before Impact

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 29

Date: 12/10/98

Time: 2:25

Conditions: Rainy 48° F

Staff: \_\_\_\_\_

Target Description:

Serial No. E-9 T-6

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 17, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

353

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Save Tile as Test 25

- Little Slow (-47)

- No Damage

- Good Shot

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 30

Date: 12/10/98

Time: 2:40

Conditions: Rainy 48°

Staff: \_\_\_\_\_

Target Description:

Serial No. Erg Tile

Obliquity (deg.): 67°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 38, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess 800fps

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Delamination

1.0" X 1.0"

Comments:

- Intended Velocity 800fps

- Same Tile - same place

- No Incon - Bad Trigger

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 30A

Date: 12/10/98

Time: \_\_\_\_\_

Conditions: Rainy 48°F

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng. Tile  
Obliquity (deg.): 67°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 38, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess 800fps

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Very small crack 1" Long at impact site

Comments:

- Same Tile - New spot

- ~~no damage~~

- No impact, no velocity

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 303

Date: 12/10/98

Time: \_\_\_\_\_

Conditions: Rainy 48°F

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng Tile  
Obliquity (deg.): (67)°  


Projectile Description:

Projectile Dimensions: 1" x 1" x 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .60

Gun Pressure (psi): P1: 600, P2: 38, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.	_____	<u>934</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Delamination 1.0" x 2.0"  
Loss of Coating

Comments:

- Small tile at 30A - same spot  
- Velocity (+134)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 31

Date: 12/10/98

Time: \_\_\_\_\_

Conditions: Rain  $48^{\circ}\text{F}$

Staff: \_\_\_\_\_

Target Description:

Serial No. F14 Tile

Obliquity (deg.): 67°

Projectile Description:

Projectile Dimensions: 1.0" x 1.0" x 1.0"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 90, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1233

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

1.25" x 2.25" x 0.25 deep

Comments:

- Good Test

- Velocity +33 fps

Post test cracks

1/1

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 32

Date: 12/10/98

Time: \_\_\_\_\_

Conditions: Rainy 48° F

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 67°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
	Ave.	<u>1557</u>

Tile Damage Assessment:

Crater (Y/N): Length: 3.75" Width: 2.25" Depth: .4"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

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Comments:

- Some tile as test 31 - new spot  
- Good test, velocity

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NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 33

Date: 12/11/98

Time: 8:30

Conditions: 43° Rainy

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 60°

Projectile Description:

Projectile Dimensions: 1" X " X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): 6

Gun Pressure (psi): P1: 600, P2: 18, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

452

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- NO Damage

- Good Test

Print + Cracks

10.17

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 34

Date: 12/10/98

Time: 4:30

Conditions: Rainy 46°F

Staff: \_\_\_\_\_

Target Description:

Serial No. FT Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess ≈ 800fps

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Intended Vel. 800fps
  - Sene Tile <sup>as</sup> <sub>Test + 35</sub> New Spot
  - No Trigger - NO Impact
- \_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 34A

Date: 12/10/98

Time: 4:40

Conditions: Rainy 46°F

Staff: \_\_\_\_\_

Target Description:

Serial No. F14 Tile

Obliquity (deg.): 60°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

805 fps

Tile Damage Assessment:

Crater (Y/N): Length: 2.0 Width: 1.25 Depth: .25

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Good Shot, Vel.

Pretest cracks  


NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 35

Date: 12/10/98

Time: 4:10

Conditions: Rainy 46°F

Staff: \_\_\_\_\_

Target Description:

Serial No. F11 Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 90, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1240

Tile Damage Assessment:

Crater (Y/N): Length: 2.25" Width: 1 3/8" Depth: .40

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Good Test, Velocity  
- Projectile Slightly Cracked -OK

Post test Crack



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 36

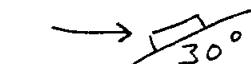
Date: 12/10/98

Time: \_\_\_\_\_

Conditions: Rainy

Staff: \_\_\_\_\_

Target Description:

Serial No. F1T Tile  
Obliquity (deg.): 60°  


Projectile Description:

Projectile Dimensions: 1" X 1" X 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>guess 1550 fps</u>

Tile Damage Assessment:

Crater (Y/N): Length: 3.0" Width: 1.0" Depth: .50"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Delamination

3.0" x 2.0"

Comments:

- New Fit Tile

- Intended Vel. 1600fps (

- No Inacons)

Pre Test Cracks

T-7

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 36A

Date: 12/10/98

Time: 3:45

Conditions: 48° F

Staff: \_\_\_\_\_

Target Description:

Serial No. F1+ Tile

Obliquity (deg.): 60°

Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1483</u>

Tile Damage Assessment:

Crater (Y/N): Length: 2.5" Width: 1.5" Depth: 0.5"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same tile as 36 new area
  - Projectile Broken up Slightly
  - Good Test
  -
- \_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 37

Date: 12/11/98

Time: 8:52

Conditions: 43° Rainy

Staff: \_\_\_\_\_

Target Description:

Serial No. F14 Tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: 1" X 1" X 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): ,6

Gun Pressure (psi): P1: 600, P2: 18, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

447

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- same tile - same spot as Test 33  
- NO Damage  
- Good Test  
\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 38

Date: 12/11/98

Time: 9:00

Conditions: 43°F

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 tile  
Obliquity (deg.): 50°  


Projectile Description:

Projectile Dimensions: 1" x 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>767</u>

Tile Damage Assessment:

Crater (Y/N): Length: 1.5" Width: 1.25" Depth: 3/8"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Same tile same spot  
- Projectile lost a small chunk

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 39

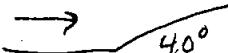
Date: 12/11/98

Time: 9:10

Conditions: 43°F

Staff: \_\_\_\_\_

Target Description:

Serial No. F11 Tile  
Obliquity (deg.): 50°  


Projectile Description:

Projectile Dimensions: 1" X " X 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 90, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.	_____	<u>1216</u>

Tile Damage Assessment:

Crater (Y/N): Length: 2.5" Width: 1.1" Depth: .5"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

---

---

Comments:

- Same Tile as Test 38 - New Spot  
- Good Test, Velocity

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 40

Date: 12/14/98

Time: 9:20

Conditions: 43° Rainy

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng Tile  
Obliquity (deg.): 50°  


Projectile Description:

Projectile Dimensions: 1" x " x 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	guess 1450

Tile Damage Assessment:

Crater (Y/N): Length: 2.0" Width: 1.5" Depth: 5/8"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- no Incon - No Ucl.

\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 40A

Date: 12/14/98

Time: 9:40

Conditions: 43° Rain

Staff: \_\_\_\_\_

Target Description:

Serial No. Eng. tile

Obliquity (deg.): 50°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1616

Tile Damage Assessment:

Crater (Y/N): Length: 3.0 Width: 1.5 Depth: .5

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Same tile as 40 new spot
- Projectile broke up some - Ok
- Incon did not trigger very well
- Still Good Test
- used Particle to determine velocity

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 41

Date: 12/28/98

Time: 11:30

Conditions: Sunny 65°F

Staff: DLG

Target Description:

Serial No. F11 Tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 19, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

409

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- same Tile as 42 - same spot

- Good Test - Good Velocity

- Lost Channel #5 on Camera - No Problem

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 42

Date: 12/28/98

Time: 11:15

Conditions: Sunny 62°f

Staff: DHG

Target Description:

Serial No. E14 Tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 42, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

809 fps

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- No Damage

Comments:

<sup>o</sup>, Test 43

- Some Tile - lower aim point

- Good Test - Good Velocity

-0

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 43

Date: 12/28/98

Time: 11:10

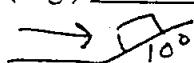
Conditions: Sunny 62° F

Staff: DLG

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1 x 1 x 3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 115, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1242

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- Very Tiny Crack at Impact site - No delamination  
of Coating



Comments:

- No Prot. of Cracking on FIT Tile
- Good Test - Good Velocity (+42) f/s
- Hit a little High - OK
- Projectile stayed together

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SwRI Project No. 06-7503-005

Test No. 44

Date: 12/28/98

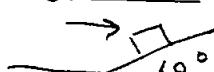
Time: 10:45

Conditions: Sunny 60° F

Staff: DLG

Target Description:

Serial No. Eng Tile  
Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1K1X3  
Projectile Weight (g): 1.77  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 170, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>1620</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- Very slight cracking at Top edge of tile  
- No damage at Impact Site

Comments:

- Same tile as Test 48C - New spot  
- Good test - Good Velocity  
- Projectile slightly broke up - cracked before impact - OK  
- Projectile hit aim point at center of tile

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 45

Date: 12/18/98

Time: 10:10

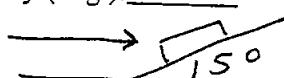
Conditions: Cloudy 56°

Staff: DLG

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: 1 x 1 x 3

Projectile Weight (g): 1.07

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 19, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

399

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

\_\_\_\_\_  
\_\_\_\_\_

Comments:

Same Tile - Same Spot as Test 49

No Damage

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 46

Date: 12/18/98

Time: 10:25

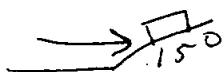
Conditions: Cloudy 57°

Staff: DLG

Target Description:

Serial No. Erg Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 42, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

853

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same Tile Same spot as Test 45

- No Damage

- Velocity (+53 fps)

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Orbiter Tile Impact Testing  
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Test No. 47

Date: 12/18/98

Time: 10:40

Conditions: Cloudy 57° F

Staff: DLG

Target Description:

Serial No. Eng tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: 1 x 1 x 3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 120, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

1451

Tile Damage Assessment:

*blow out edge  
of tile*

Crater (Y/N): Length: 3.1" Width: 1.3" Depth: 0.5"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Same tile - same spot as Test 46

- Too fast

- Good Test

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 47A

Date: 12/18/98

Time: 10:40

Conditions: Cloudy 57°

Staff: DG

Target Description:

Serial No. F17 tile

Obliquity (deg.): 15°



Projectile Description:

Projectile Dimensions: 1x1x3"

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 105, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1122

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

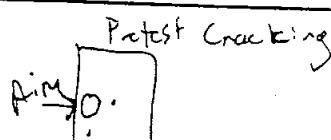
Tile Cracking (Y/N - Describe):

Delamination of Coating L = 1.5" w = 1.0"

Star Cracking

Comments:

- Good test, (Vel. ~ 18 fps)



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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 48

Date: 12/8/98

Time: 10:55

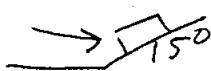
Conditions: cloudy 59°

Staff: DLG

Target Description:

Serial No. F1T Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 150, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

1273

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- 1.5" dia delamination - some coating came off
- Coating thickness - cavity depth

Comments:

- Same Tile as Test 47A - New spot

- Slow (~229 fps)

- Projectile ~~was~~ split a little

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SwRI Project No. 06-7503-005

Test No. 48A

Date: 12/18/98

Time: 11:05

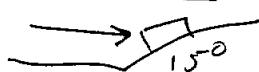
Conditions: Cloudy 60°

Staff: DLG

Target Description:

Serial No. Erg Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: 1x1 x 3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 185, P3: 600

Velocity Measurement:

Measurement

1

2

Time (us)

\_\_\_\_\_

\_\_\_\_\_

Velocity (fps)

\_\_\_\_\_

\_\_\_\_\_

Ave.

~1500 guess

Tile Damage Assessment:

Crater (Y/N): Length: 4.0" Width: 1.3" Depth: .4"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Pat triggered  
- No impact

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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 48B

Date: 12/18/98 Re

Time: 11:15

Conditions: Cloudy 60°

Staff: JLG

Target Description:

Serial No. Ery Tile

Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: 1 x 1 x 3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 185, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_ guess 1500

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- very slight cracking at top edge of tile



Comments:

New tile - New spot

~~Projectile broke up~~

- no Data

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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 48C

Date: 12/28/98

Time: 10:30

Conditions: Sunny 60°F

Staff: DLG

Target Description:

Serial No. Erg Tile  
Obliquity (deg.): 75°



Projectile Description:

Projectile Dimensions: 1x1x3  
Projectile Weight (g): 1.97  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: ████, P3: 600  
170

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1526</u>

Tile Damage Assessment:

Blew out ~~edge~~ of tile

Crater (Y/N): Length: 3.35" Width: 1.25" Depth: ~0.5"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- 
- 
- 
- Comments:
- Same tile - ~~Same~~ Slightly Lower Impact Spot
  - Good Test - Good Velocity (~ 14 f/s)
  - Projectile stayed together
- 
-

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 49

Date: 12/18/98

Time: 10:00

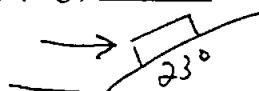
Conditions: Cloudy 55° F

Staff: DLG

Target Description:

Serial No. Erg tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 20, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

440

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) Describe:

No Damage

Comments:

- Same tile as Test SOA - New spot

- Good Velocity (+440 fps)

- No Damage

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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 50

Date: 12/17/98

Time: 5:05

Conditions: Sunny 60° F

Staff: DLG

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 67°

→ 23°

Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 45, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

920

Tile Damage Assessment:

Crater (Y/N): Length: 1.46" Width: 1.36" Depth: .15"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Good Test - Slightly Fast (+120 fps)  
- slight Damage

\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 50A

Date: 12/18/98

Time: 9:15

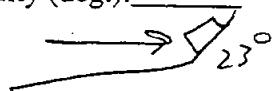
Conditions: Cloudy 55°

Staff: \_\_\_\_\_

Target Description:

Serial No. Erg Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: 1X1X3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 40, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

723

Tile Damage Assessment:

Crater (Y/N): Length: 1.8 " Width: 1.1 " Depth: .2 "

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

\_\_\_\_\_

Comments:

- Good Test - Good Velocity (- 77 fps)

\_\_\_\_\_

\_\_\_\_\_

Protect Cracks



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SwRI Project No. 06-7503-005

Test No. 51

Date: 12/17/98

Time: 4:05

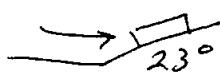
Conditions: Sunny 65°

Staff: DL G

Target Description:

Serial No. F17 tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: 1" x 1" x 3"

Projectile Weight (g): 1.72

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess ~~1350~~  
1350

Tile Damage Assessment:

Crater (Y/N): Length: 4.0 Width: 1.1 Depth: .71"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_

Comments:

- No Imacon - No Velocity Pretrigger  
- Big Damage

Post test cracks

1.57

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 51A

Date: 12/17/98

Time: 4:20

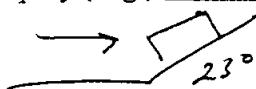
Conditions: sunny 65°F

Staff: DLG

Target Description:

Serial No. F14 Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: "1x1x3"

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

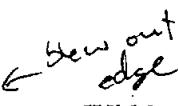
\_\_\_\_\_

Ave.

\_\_\_\_\_

~~guess 1200~~  
1350

Tile Damage Assessment:

Crater (Y/N): Length: 4.0  Width: 1.25 Depth: .55

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Sam Tile - New Spot
  - Pretrigger - No Impact
- \_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 51B

Date: 12/17/98

Time: 4:50

Conditions: Sunny 65°

Staff: \_\_\_\_\_

Target Description:

Serial No. F1+ Tile

Obliquity (deg.): 67°

→ 2.3°

Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1356

Tile Damage Assessment:

Crater (Y/N): Length: 4.25" ← *Blew out edge of tile* Width: 1.3" Depth: .63"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):  
\_\_\_\_\_  
\_\_\_\_\_

Comments:

*Good Test*

*- Probably Test 51 & 51A had similar Velocities*

*Post test cracks*

*1/1*

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 52

Date: 12/17/98

Time: 3:05

Conditions: Sunny 65°

Staff: DLG

Target Description:

Serial No. F14 Tile  
Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: 1x1x3"  
Projectile Weight (g): 1.77  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): 1.77

Gun Pressure (psi): P1: 600, P2: 185, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess = 1400

Tile Damage Assessment:

Crater (Y/N): Yes Length: 4.4" Width: 2.0" Depth: .30" - Looks like projectile may have broke up.

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_

Comments:

- Same Tile as Test 56 - New Spot
- No Tracon - No Velocity

Post test cracking

→ ← Aim Point

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 52 A

Date: 12/17/98

Time: 3:25

Conditions: Sunny 65°F

Staff: DLG

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 67°

23°

Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): 1.77"

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 185, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1350

Hard to go any faster

Tile Damage Assessment:

Crater (Y/N): Length: 4.25" Width: 2.0" Depth: .35"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Projectile Broke Up - Still Good Test  
- Velocity (-250 fps)  
- Redue as 52 B

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 52B

Date: 12/17/98

Time: 4:00

Conditions: Sunny 65°F

Staff: \_\_\_\_\_

Target Description:

Serial No. Fit Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: (1x1x3")

Projectile Weight (g): 1.02

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 120, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1588



Tile Damage Assessment:

Crater (Y/N): Length: 4.0" ← removed long tile section of edge Width: 1.1" Depth: .80"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

\_\_\_\_\_

Comments:

- Good Test - Good Velocity

- Used as 52B due to high velocity

- Projectile stayed "whole"

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 53

Date: 12/11/98

Time: 11:20

Conditions: 43°

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 1x1x3

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): 1.17

Gun Pressure (psi): P1: 600, P2: 20, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

410

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) – Describe:

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same Fit Tile as Test 57A
- New Spot
- No Damage
- Good Test

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 54

Date: 12/19/98

Time: 10:50

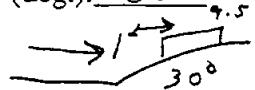
Conditions: Sunny 65°

Staff: DLG

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 1" x 1" x 3"

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 45, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>803</u>

Tile Damage Assessment:

Crater (Y/N): Length: 2.0" Width: 1.25" Depth: .08"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Good Test, Velocity
- Projectile Stayed Together

Pretest Cracking

Front → 0.7 → Z-RDM

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 55

Date: 12/17/98

Time: 11:05

Conditions: Sunny 65°

Staff: DG

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 1" x 1" x 3"

Projectile Weight (g): 1.77

Sabot Weight (g):  

Total Weight (g): 1.77

Gun Pressure (psi): P1: 600, P2: 115, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1161

Tile Damage Assessment:

Crater (Y/N): Length: 3.65 " Width: 1.5 " Depth: .75 " ave.

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

*Damage void blew out edge of tile*

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same tile as Test 54 - New spot

- Good Test, velocity

- A little blow by gas hit target first - debris moving

in Inacor image at old damage site - No problem!

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 56

Date: 12/17/98

Time: 11:40

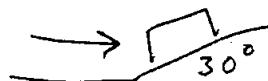
Conditions: Sunny 65°F

Staff: DIG

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 1x1x3"

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 185, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1386

Tile Damage Assessment:

Crater (Y/N): Length: 4.125" Width: 2.75" Depth: .60"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)  
*Delamination of Coating*

*slightly shallow  
because project  
broke up. Resulted  
in wider damage  
area*

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Good test, velocity (~214 fps)
- Projectile split during flight - ok still hit same spot

*Post cracking*

*[A] along edge only*

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 57

Date: 12/11/98

Time: 11:10

Conditions: 43° F cloudy

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 Tile  
Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: "1x1x3"  
Projectile Weight (g): 1.77  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 22, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	guess 400 fps

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

\_\_\_\_\_  
\_\_\_\_\_

Comments:

\* No Invasion - No Damage  
\_\_\_\_\_  
\_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Post-test cracking

None

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 57A

Date: 12/14/98

Time: 11:15

Conditions: 47°F

Staff: \_\_\_\_\_

Target Description:

Projectile Description:

Serial No. F17 Tile

Projectile Dimensions: 1x1x3

Obliquity (deg.): 50°

Projectile Weight (g): \_\_\_\_\_

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): 1.22

Gun Pressure (psi): P1: 600, P2: 22, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

467

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

3/4" dia - slight depression 1/8" deep

Comments:

- Same Tile <sup>as 57</sup> - same spot
- Good Test

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 58

Date: 12/4/98

Time: 9:55

Conditions: 43° Rainy

Staff: \_\_\_\_\_

Target Description:

Serial No. F11 Tile

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: 1" x 1" x 3"

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 45, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

801

Tile Damage Assessment:

Crater (Y/N): Length: 2.5" Width: 1.2" Depth: .4"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Good Shot, vel.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Prtest Cracks

FOA

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 59

Date: 12/11/88

Time: 10:05

Conditions: 43° F Rainy

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 50°

Projectile Description:

Projectile Dimensions: "x" "x" 3"

Projectile Weight (g): 1.79

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess  
1200

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

Save tile - new spot  
- No Images - No Velocity  
- mega Damage

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 59A

Date: 12/11/98

Time: 10:15

Conditions: 40° F

Staff: \_\_\_\_\_

Target Description:

Serial No. F17 Tile  
Obliquity (deg.): 60.50°

Projectile Description:

Projectile Dimensions: "1x1x3"  
Projectile Weight (g): 1.77  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1126

Tile Damage Assessment:

Crater (Y/N): Length: 4.5" Width: 2.0" Depth: 1.0"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- Good Test
- (- 74 fps)

Post Crack  
10.

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 60

Date: 12/4/98

Time: 10:30

Conditions: 43°F Range Cloudy

Staff: \_\_\_\_\_

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 50°

Projectile Description:

Projectile Dimensions: 1x1x3"

Projectile Weight (g): 1.77

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 200, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1432

Tile Damage Assessment:

Crater (Y/N): Length: 6.0" Width: 2.0" Depth: 2.0"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- New FIT Tile

- Good Test

- Projectile Broke up - Big Pieces

Patent Cracks

10.7 repair

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 81

Date: 12/31/98

Time: 10:30

Conditions: Cloudy 63°F

Staff: SLC

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 80°



Gun Pressure (psi): P1: 600, P2: 600, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

\_\_\_\_\_

750

Tile Damage Assessment:

Crater (Y/N) Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- Same tile as Test 20F - New Spot  
- Good Test - Velocity (~50 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 82

Date: 12/3/98

Time: 10:50

Conditions: Cloudy 64°

Staff: DG

Target Description:

Serial No. F14 Tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: .89" X .81" X .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1553

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

No Damage

Comments:

- Same Tile as Test #81 - same spot  
- Good Test - Good Velocity (-47 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Date: 11/7/99  
Time: 2:20  
Conditions: Cloudy 65°  
Staff: Dale

Test No. 83

Target Description:

Serial No. Eng Tile  
Obliquity (deg.): 80°  


Projectile Description:

Projectile Dimensions: 1" X 1" X 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .644

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>790</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- New Tile
- Good Test - Velocity (~10 fps)
- Projectile Impacted Target Properly - Inacon does not show Impact - Timing wrong!

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 84

Date: 1/7/98

Time: 2:40

Conditions: Cloudy 65° F

Staff: DLG

Target Description:

Serial No. Erg Tile  
Obliquity (deg.): 80°  


Projectile Description:

Projectile Dimensions: 1" x 1" x 1"  
Projectile Weight (g): .64g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 175, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1425</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- 
- 
- 
- Comments:
- Same tile as Test No. 83 - same spot
  - Project Broke Up
  - Velocity (~175 fps)
- 
-

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 84A

Date: 1/9/99

Time: 2:50

Conditions: Cloudy 65°

Staff: DLC

Target Description:

Serial No. Erg Tile  
Obliquity (deg.): 80°  


Projectile Description:

Projectile Dimensions: 1x1x1  
Projectile Weight (g): .64g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1464</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- Same tile - same spot  
- Good Test - Velocity (~136 fps)  
Projectile very slightly broken up

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 84B

Date: 1/9/99

Time: 3:00

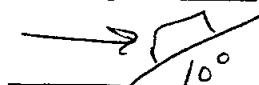
Conditions: Cloudy 65°

Staff: DLG

Target Description:

Serial No. FIT tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1 x 1 x 1

Projectile Weight (g): .645

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 700, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

1710

Tile Damage Assessment:

Crater (Y/N): Length: 2.25" Width: 1.63" Depth: 0.10"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Very shallow crater - mainly coating came off!

Comments:

- New FIT Tile
- Try this Tile instead of Eng Tile
- Velocity (1710 fps)
- Good test

Post-test Cracking An Pt,

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 85

Date: 11/7/99

Time: 3:15

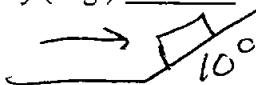
Conditions: PCloudy 61°

Staff: DLG

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: 1" x 1" x 3"

Projectile Weight (g): 1.773

Sabot Weight (g):  

Total Weight (g):  

Gun Pressure (psi): P1: 600, P2: 42, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

980

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- No Damage

Comments:

-Same Tile as Test 84B- New spot

-Good Test - Velocity (+180 ft/s)

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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

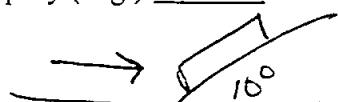
Test No. 86

Date: 1/7/99  
Time: 3:30  
Conditions: Sunny 68°  
Staff: DLG

Target Description:

Serial No. F17 tile

Obliquity (deg.): 80°



Projectile Description:

Projectile Dimensions: "x" "x" "3"

Projectile Weight (g): 1.91

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 175, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.	_____	<u>1517</u>

Tile Damage Assessment:

Crater (Y/N): Length: 2.56 " Width: 1.7 " Depth: 0.11 "

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

- Void extended to tile edge

- Mainly Coating Removed - Shallow void

Comments:

- Same Tile as Test #85 - same spot

- Good Test Velocity (~23 fps)

- Projectile looked Good - very slight cracking

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 89

Date: 12/31/98

Time: 1:00

Conditions: Cloudy 66°

Staff: DLG

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: .89" X .89" X .25"

Projectile Weight (g): .11 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>785</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N) - Describe:

No Damage

Comments:

- Pretest Cracking
- Good Test - Good Velocity (-15 fps)

A.m.  
P.M.  
X

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 090

Date: 12/31/98

Time: 11:00

Conditions: Cloudy 64°

Staff: DLC

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: .89" X .89" X .25"

Projectile Weight (g): 119

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>1400</u>

Tile Damage Assessment:

Crater (Y/N): Length: .9" Width: 1.2" Depth: .15"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Save Tile as Test #82 - New Spot
- Good Test a little slow (~ 200 fps)

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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 90A

Date: 12/31/98

Time: \_\_\_\_\_

Conditions: Cloudy 64°

Staff: DLG

Target Description:

Serial No. Eng tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: .89" x .89" x .25"

Projectile Weight (g): .11g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 200, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1315

Tile Damage Assessment:

Crater (Y/N): Length: .67" Width: .95" Depth: .13"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_

Comments:

- New Eng tile  
- Too slow

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 90B

Date: 12/31/98

Time: 12:30

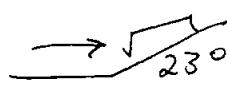
Conditions: Cloudy 66°

Staff: DLG

Target Description:

Serial No. Ekg Tile

Obliquity (deg.): 69°



Projectile Description:

Projectile Dimensions: .89 X .89 X .25

Projectile Weight (g): .11 g

Sabot Weight (g):  

Total Weight (g): 250

Gun Pressure (psi): P1: 600, P2: 2000, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

2

Ave.

1640

Tile Damage Assessment:

Crater (Y/N): Length: 1.1" Width: 1.15" Depth: .11"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- same tile as Test 90A - New Spot  
- Good Test - Velocity (+40 fps)

\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 91

Date: 1/7/99

Time: 3:45

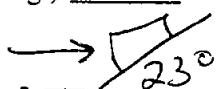
Conditions: Sunny 68°

Staff: DHG

Target Description:

Serial No. F17 tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: "x" "x" "1"

Projectile Weight (g): .64 g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

794

Tile Damage Assessment:

Crater (Y/N): Length: 1.7" Width: .21 Depth: 0.24"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

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Comments: Pretest cracking   
-Good Test - Velocity (- 6 f/s)

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NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 92

Date: 1/7/99

Time: 3:50

Conditions: Sunny 69°

Staff: DLG

Target Description:

Serial No. Fit Tile

Obliquity (deg.): 67°



Projectile Description:

Projectile Dimensions: 1x1x1

Projectile Weight (g): .64g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 190, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
	Ave.	<u>1596</u>

Tile Damage Assessment:

Crater (Y/N): Length: 3.35" Width: 1.4" Depth: 0.40"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same Fit Tile as Test 91 - new spot

- Good Test - Velocity (-4 fps)

- Projectile slightly broken up - very slightly

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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 93

Date: 1/7/99

Time: 4:15

Conditions: Sunny 50°

Staff: DLG

Target Description:

Projectile Description:

Serial No. \_\_\_\_\_

Projectile Dimensions: 1 X 1 X 3

Obliquity (deg.): 69°

Projectile Weight (g): 1,179



Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 40, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

\_\_\_\_\_

Ave.

870

Tile Damage Assessment:

Crater (Y/N): Length: 2.25" Width: 1.32" Depth: 0.27"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

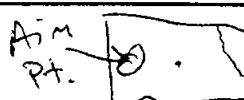
Tile Cracking (Y/N – Describe):

\_\_\_\_\_

\_\_\_\_\_

Comments:

- Pretest Cracking  
- Good Test - Velocity (+20 f/s)



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 94

Date: 11/19/99  
Time: 4:30  
Conditions: Sunny 70°  
Staff: DLG

Target Description:

Serial No: Fit Tile  
Obliquity (deg.): 69°  


Projectile Description:

Projectile Dimensions: "1" "1" "3"  
Projectile Weight (g): 1.77  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 175, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>~1380</u> °

Tile Damage Assessment:

Crater (Y/N): Length: 3.45" Width: 2.66" Depth: 0.30"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same Tile as Test #93 - New Spot
- Projectile broke up - Bad Test

\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 94A

Date: 1/7/99  
Time: 4:45  
Conditions: Sunny 69°  
Staff: DLC

Target Description:

Serial No. FIT Tile  
Obliquity (deg.): 67°  


Projectile Description:

Projectile Dimensions: 1x1x3  
Projectile Weight (g): 1.77  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 170, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1520</u>

Tile Damage Assessment:

Crater (Y/N): Length: 5.02" Width: 1.61" Depth: 0.65"

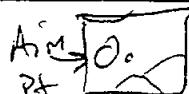
Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

Damage Extended to edge of tile

Comments:

- Pre-test Cracking
- Good Test Velocity (~80 fps)
- Projectile Slightly cracked at back end



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Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 97

Date: 1/5/99

Time: 10:30

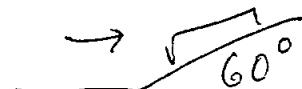
Conditions: Cloudy 46°F

Staff: DLG

Target Description:

Serial No. F17 Tile

Obliquity (deg.): 30°



Projectile Description:

Projectile Dimensions: 3/8" dia x 1.0" Length

Projectile Weight (g): 100g, 0.8g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1000

Tile Damage Assessment:

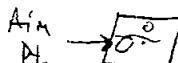
Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

0.53" dia x 0.35" deep

Comments:



- Post Cracking - ~~was in vicinity of impact~~
- Good Test - Velocity (- 9 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 98

Date: 1/5/98

Time: 4:00

Conditions: sunny 55

Staff: DLC

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 60



Projectile Description:

Projectile Dimensions: 3/8" X 1.0"

Projectile Weight (g): .08g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 160, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

1803

Tile Damage Assessment:

Crater (Y/N): Length: 1.0" Width: 0.53" Depth: 0.3"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Same T.L as Test 90B - New Spot
- Good Test - Velocity (+ 183 fps)



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 98 A

Date: 1/5/98

Time: 4:15

Conditions: Sunny 55°

Staff: DLG

Target Description:

Serial No. F1T Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 3/8" dia X 1.0"

Projectile Weight (g): .08

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 140, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.	_____	<u>1692</u>

Tile Damage Assessment:

Crater (Y/N): Length: 1.07" Width: 0.56" Depth: 0.36"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

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Comments:

- PreTest Cracking
- Velocity (+726ps)
- Good Test

Aim  
Pt → 10.1

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NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 99

Date: 1/5/99

Time: 11:15

Conditions: Cloudy 46° F

Staff: DLG

Target Description:

Serial No. FH tile

Obliquity (deg.): 30°



Projectile Description:

Projectile Dimensions: 3/8" dia x 1.0"

Projectile Weight (g): .08

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 40, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

No time

too fast

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

0.6" dia x 0.32" deep

Comments:

- Same FH tile as Test # New 97 - New spot
- Too fast

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 99 A

Date: 1/5/99

Time: 3:15

Conditions: Sunny 55°

Staff: DLG

Target Description:

Serial No. F1174

Obliquity (deg.): 30°



Projectile Description:

Projectile Dimensions: 3/8" dia x 1.0" Long

Projectile Weight (g): .089

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 35, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

8660

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

0.58" dia x 0.35" dep

Comments:

- Good Test

- Fast velocity (+131 fps)

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 99B

Date: 1/5/99

Time: 3:35

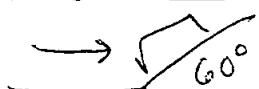
Conditions: Sunny 55°

Staff: DL(x)

Target Description:

Serial No. F17 tile

Obliquity (deg.): 30°



Projectile Description:

Projectile Dimensions: 3/8" x 1.0"

Projectile Weight (g): .08

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 20\*, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

730

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

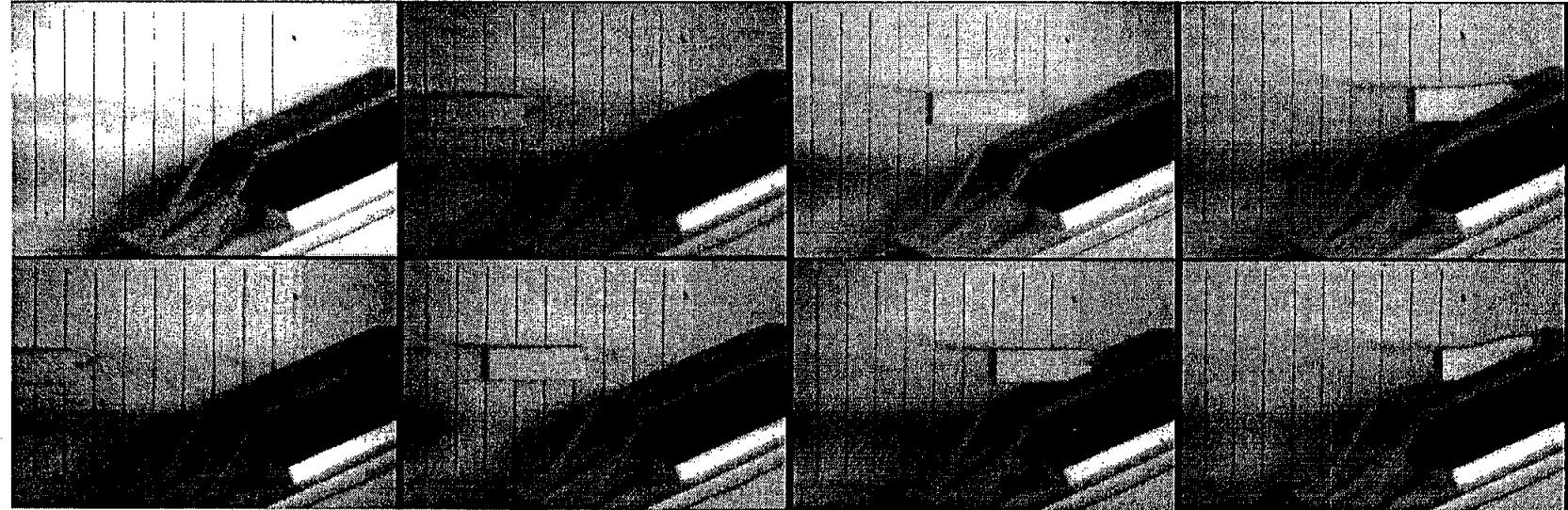
Tile Cracking (Y/N - Describe):

0.62" dia x 0.15" deep

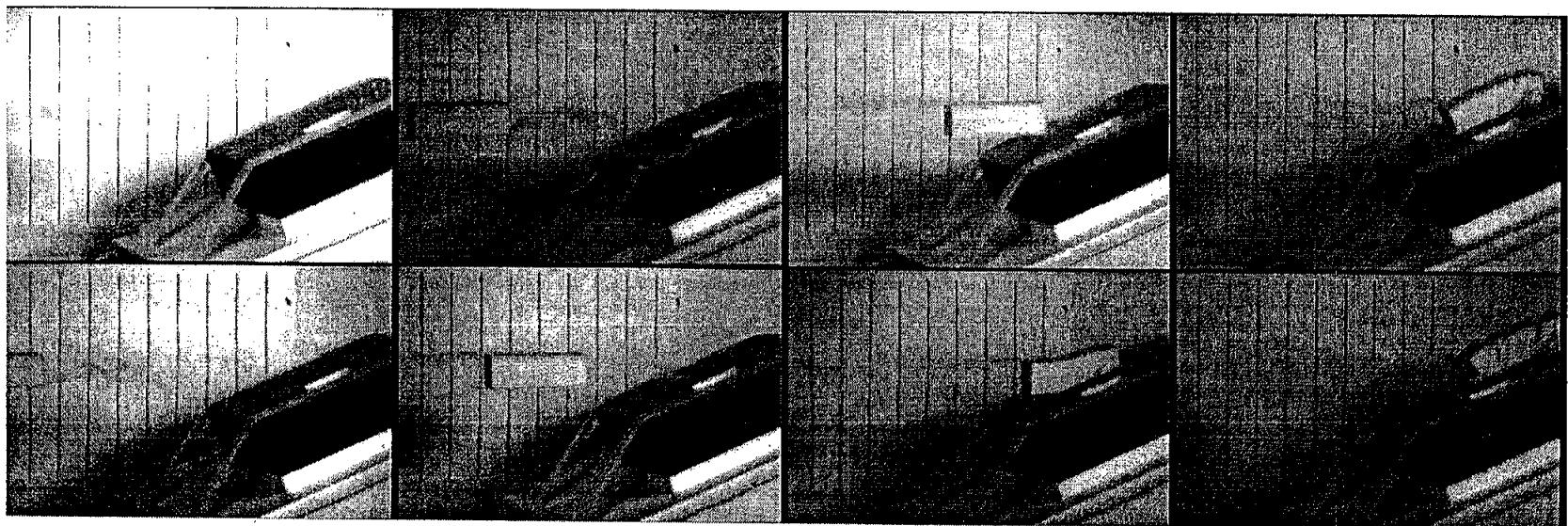
Comments:

- Same tile as Test # New 99A - new spot

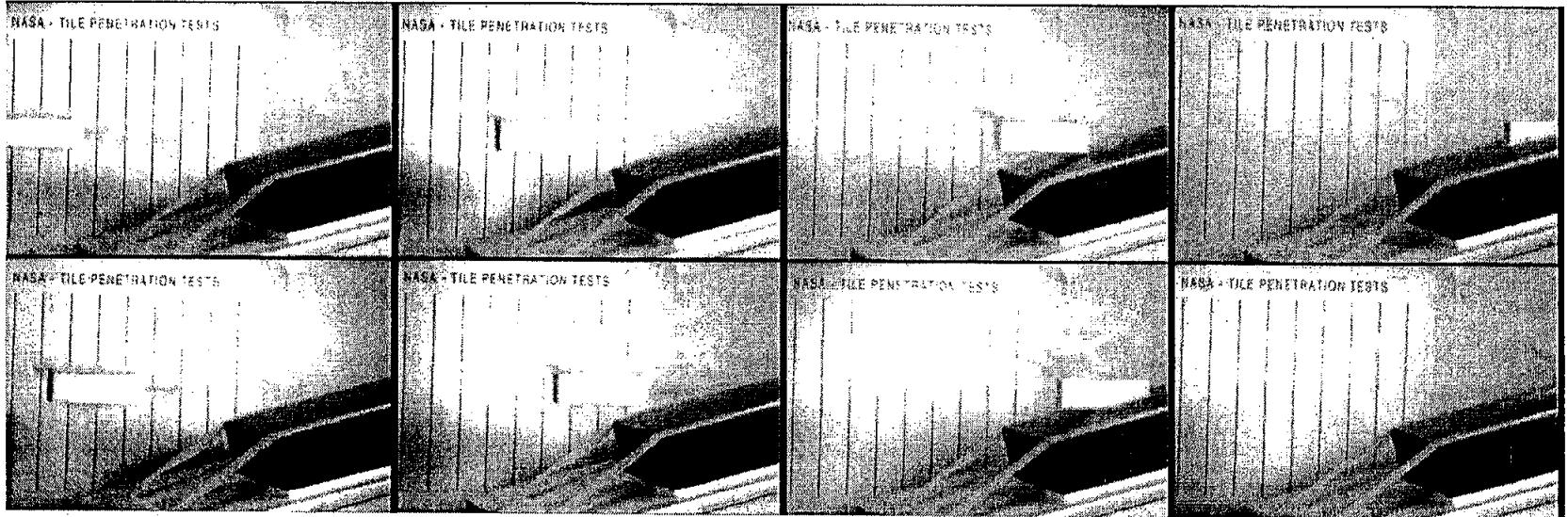
- Good Test Velocity (- 5 fps)



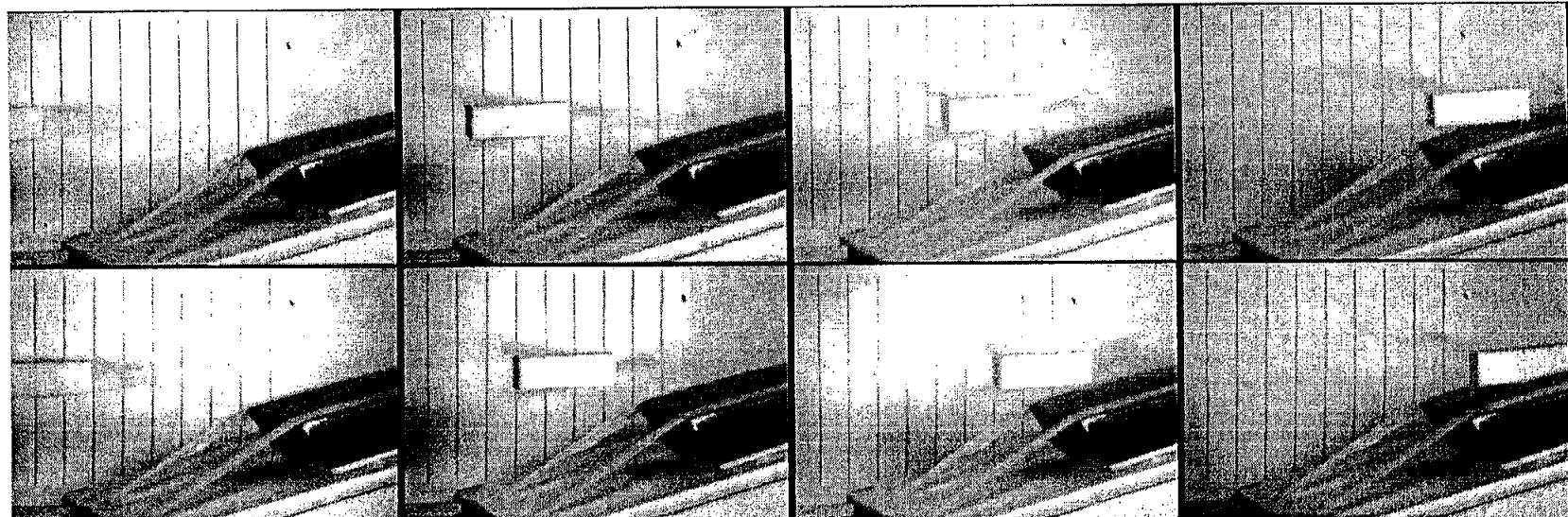
**Test No. 50A**



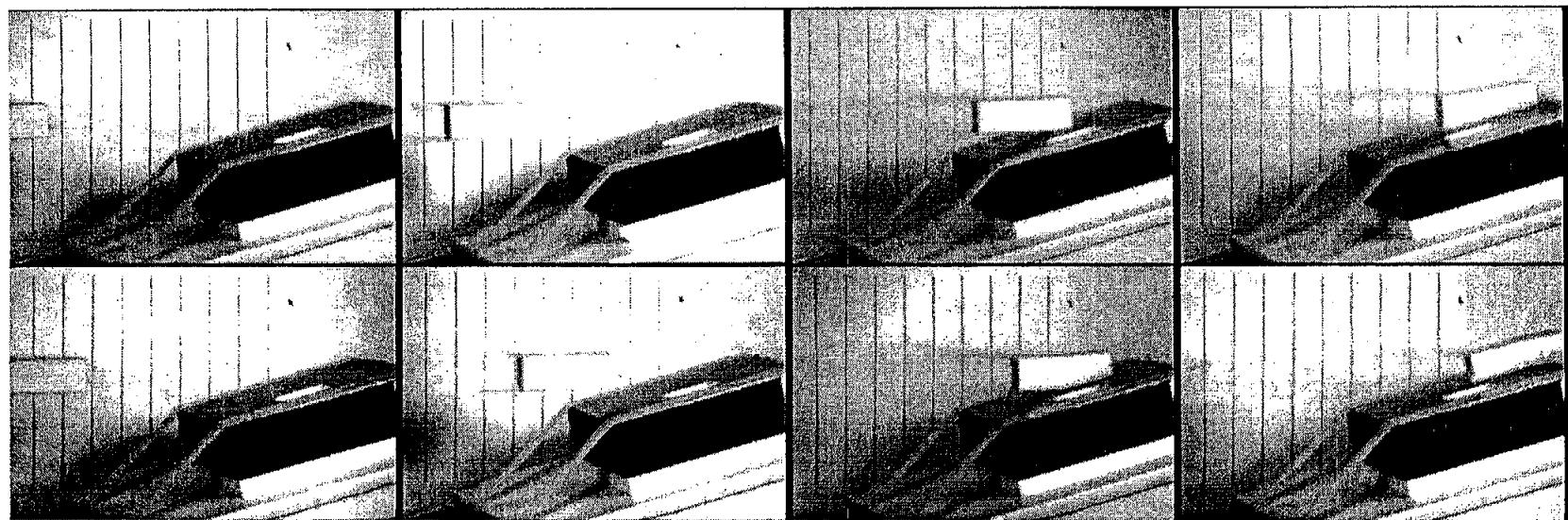
**Test No. 49**



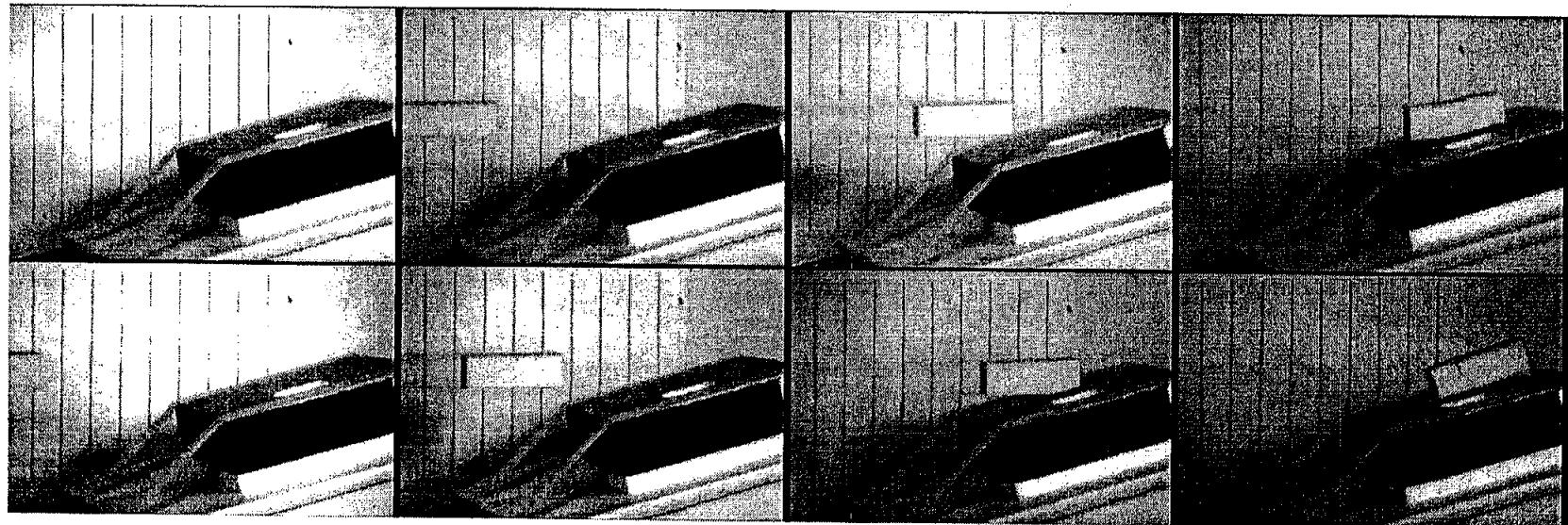
**Test No. 48C**



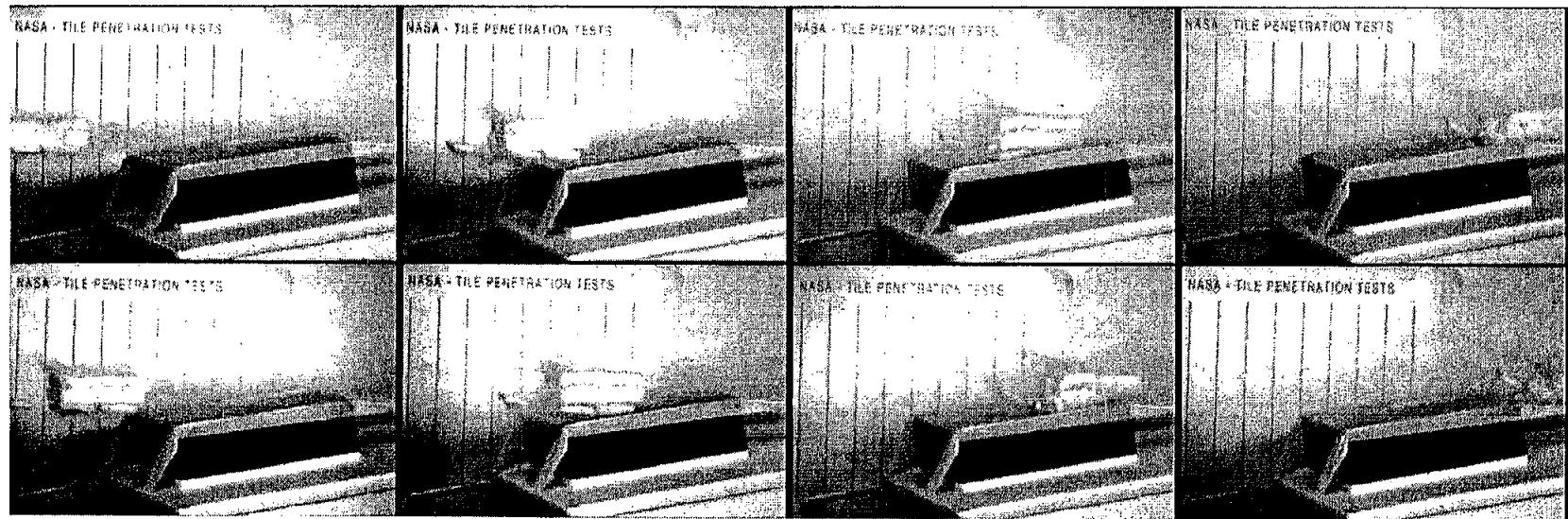
**Test No. 47A**



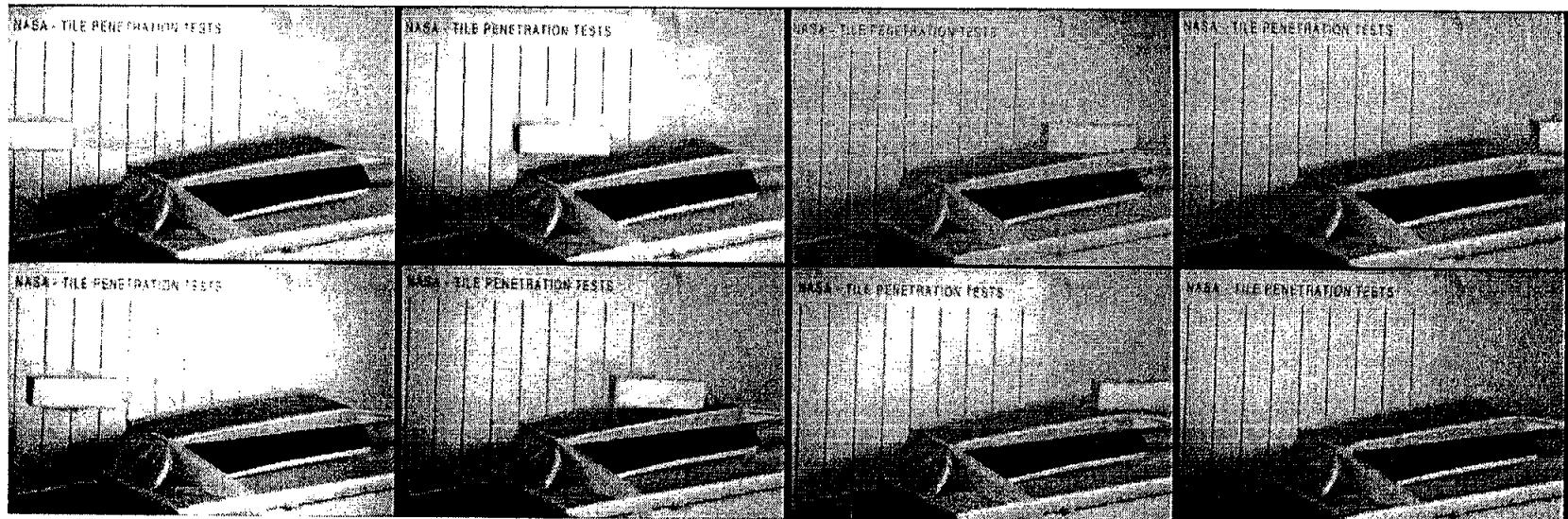
**Test No. 46**



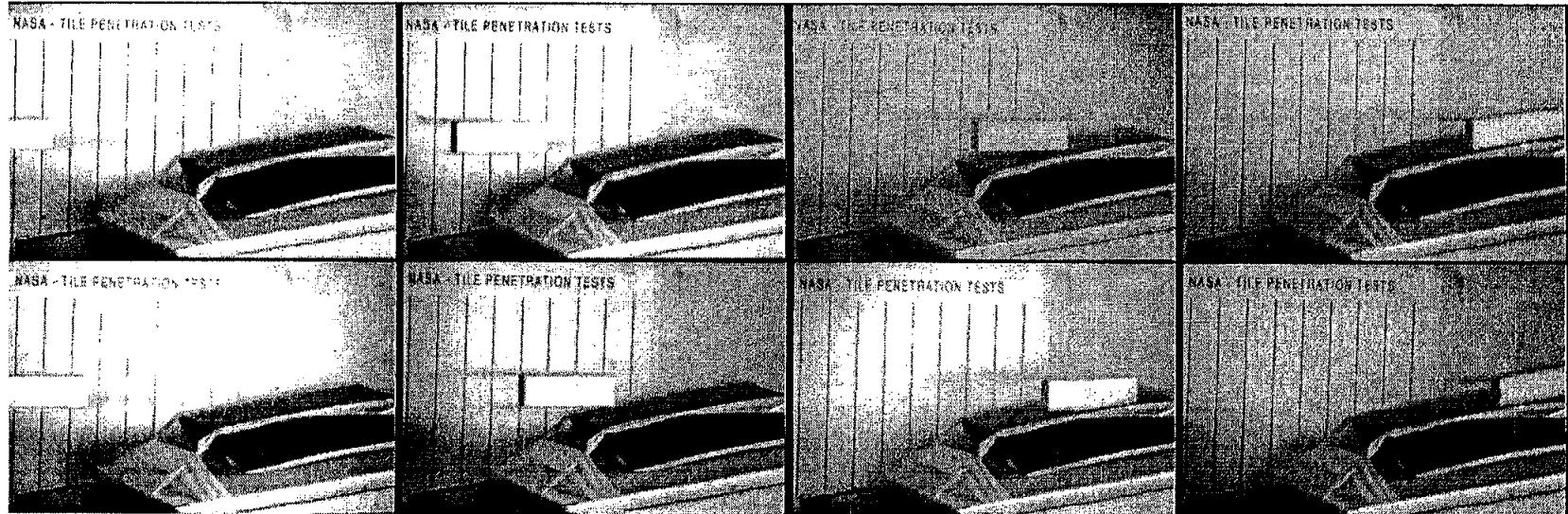
**Test No. 45**



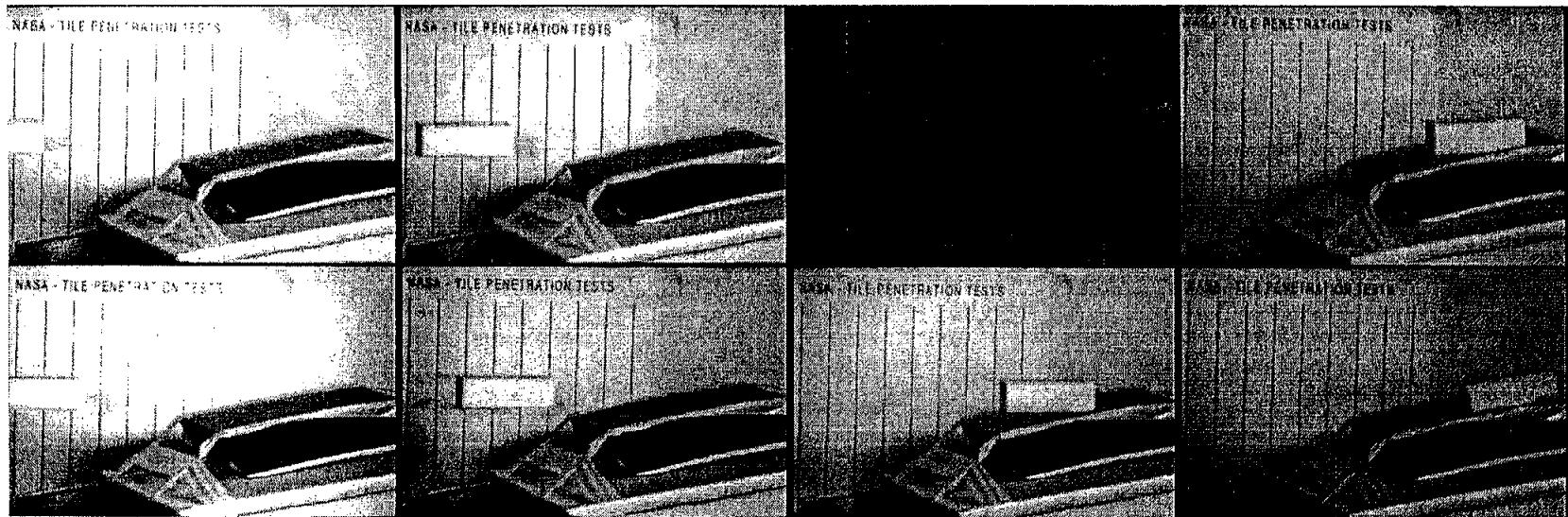
**Test No. 44**



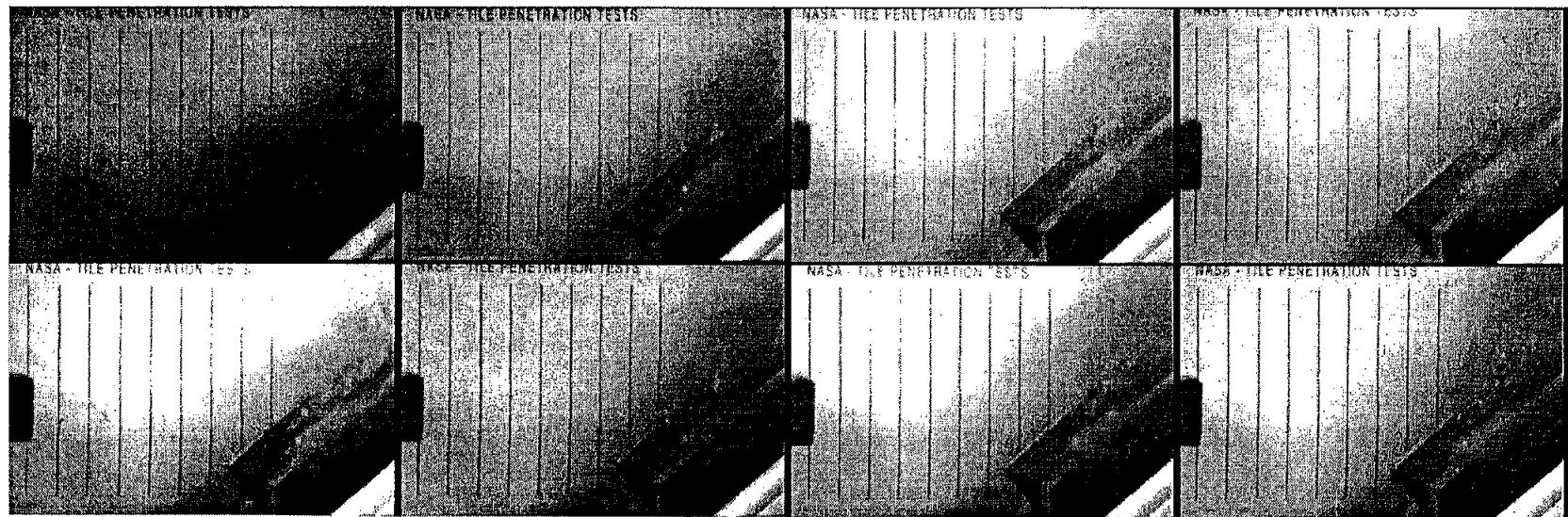
**Test No. 43**



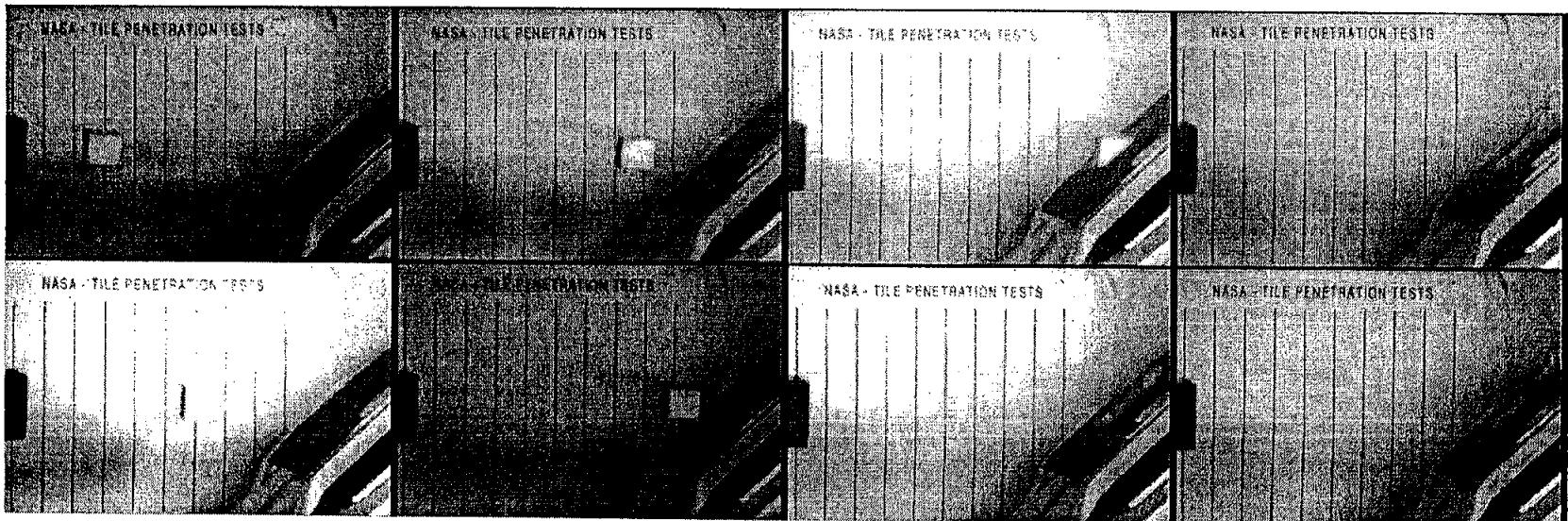
**Test No. 42**



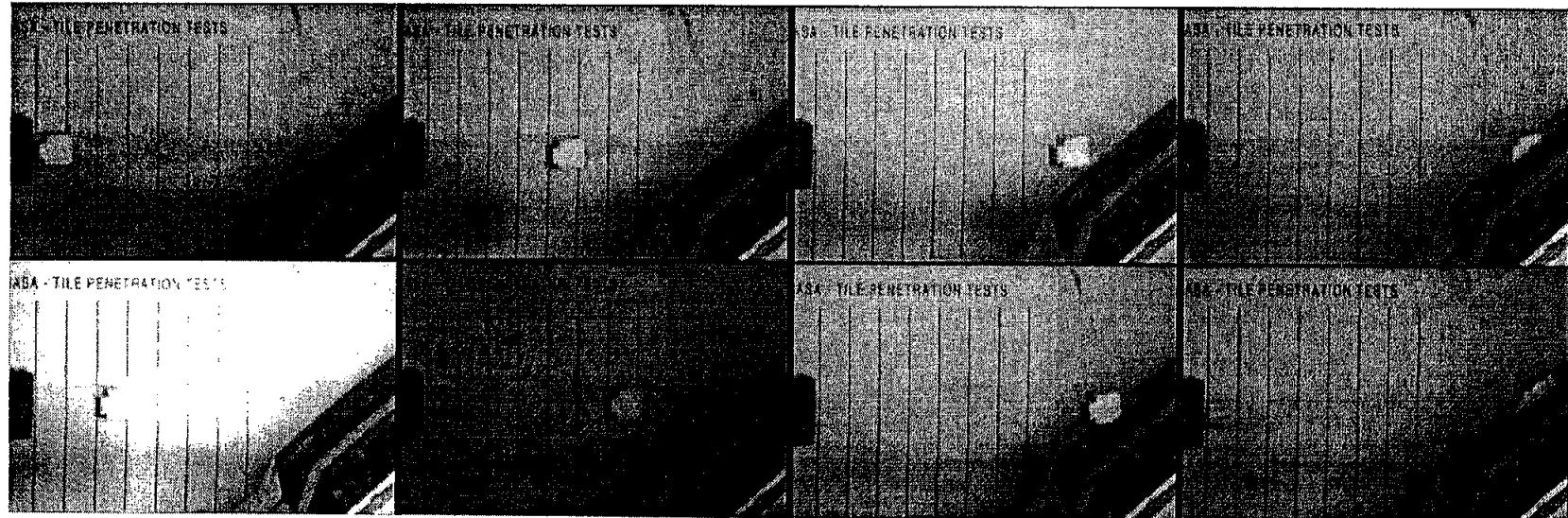
**Test No. 41**



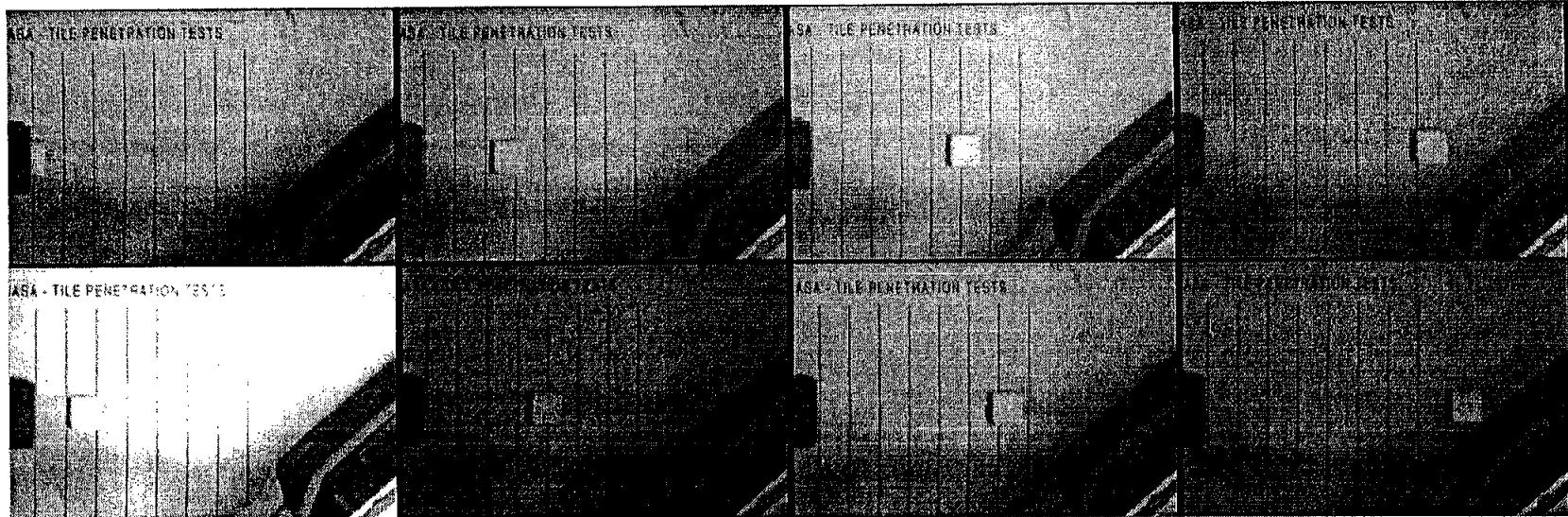
**Test No. 40A**



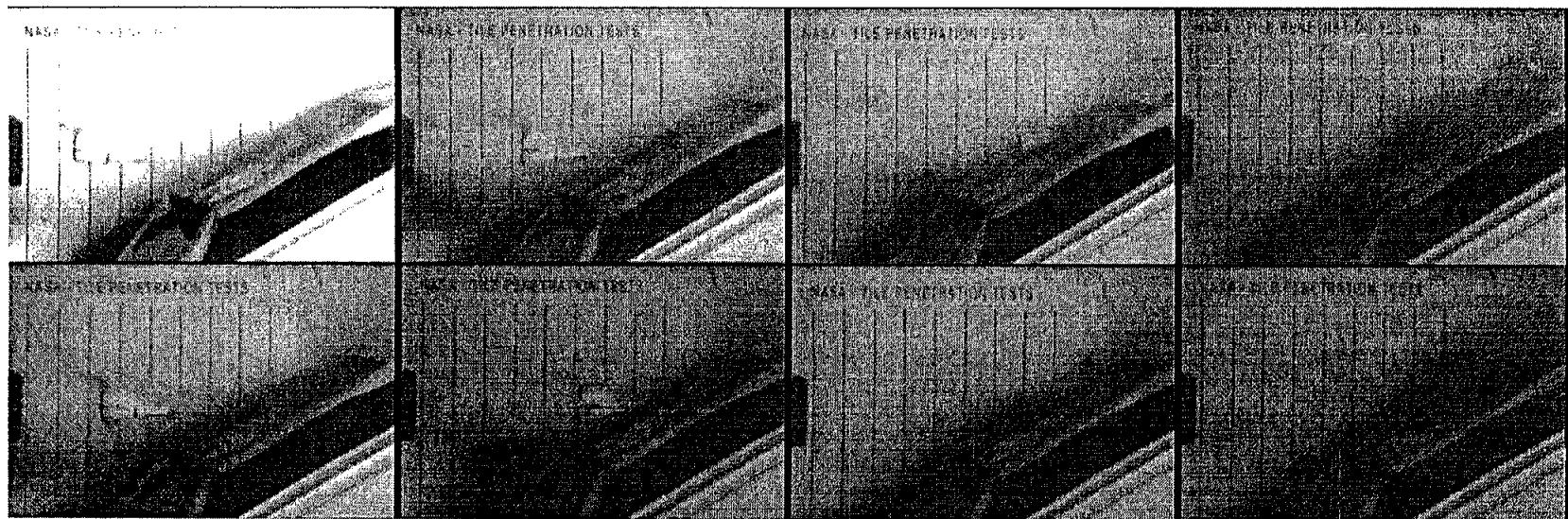
**Test No. 39**



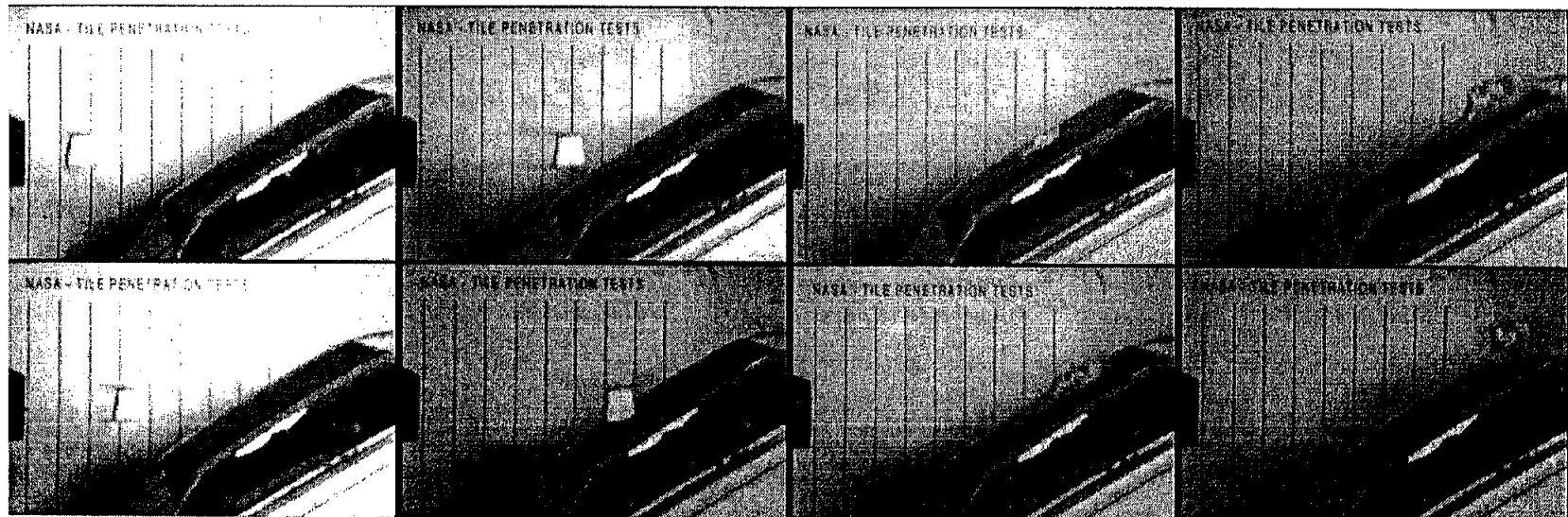
**Test No. 38**



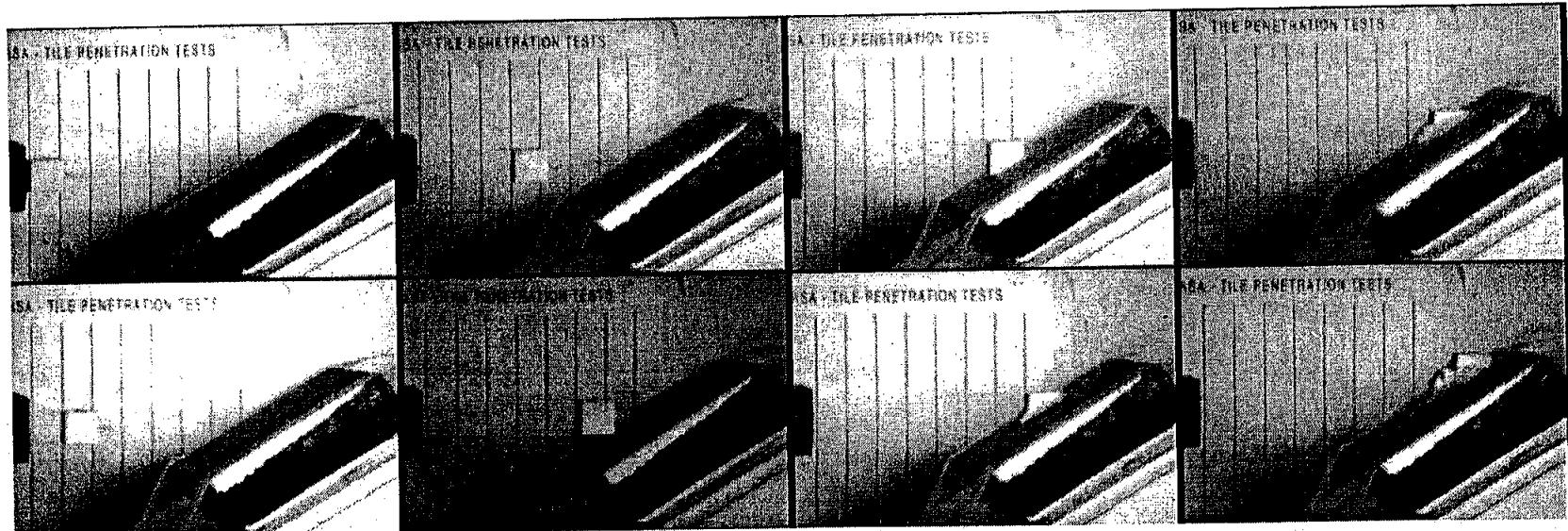
**Test No. 37**



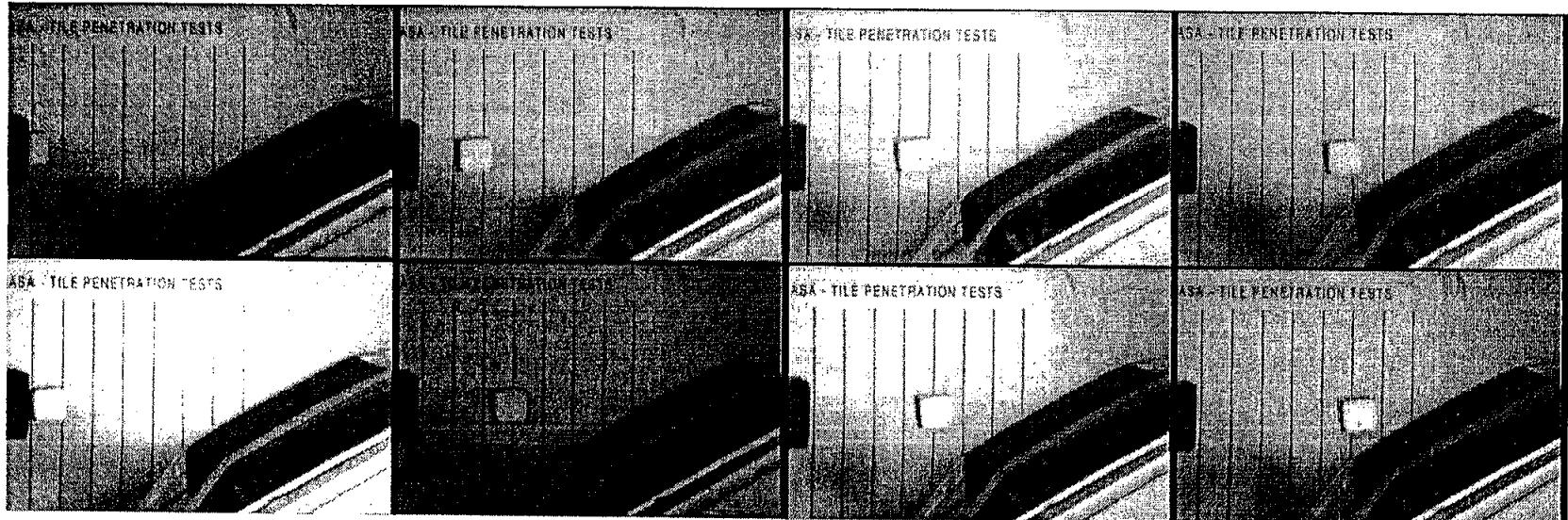
**Test No. 36A**



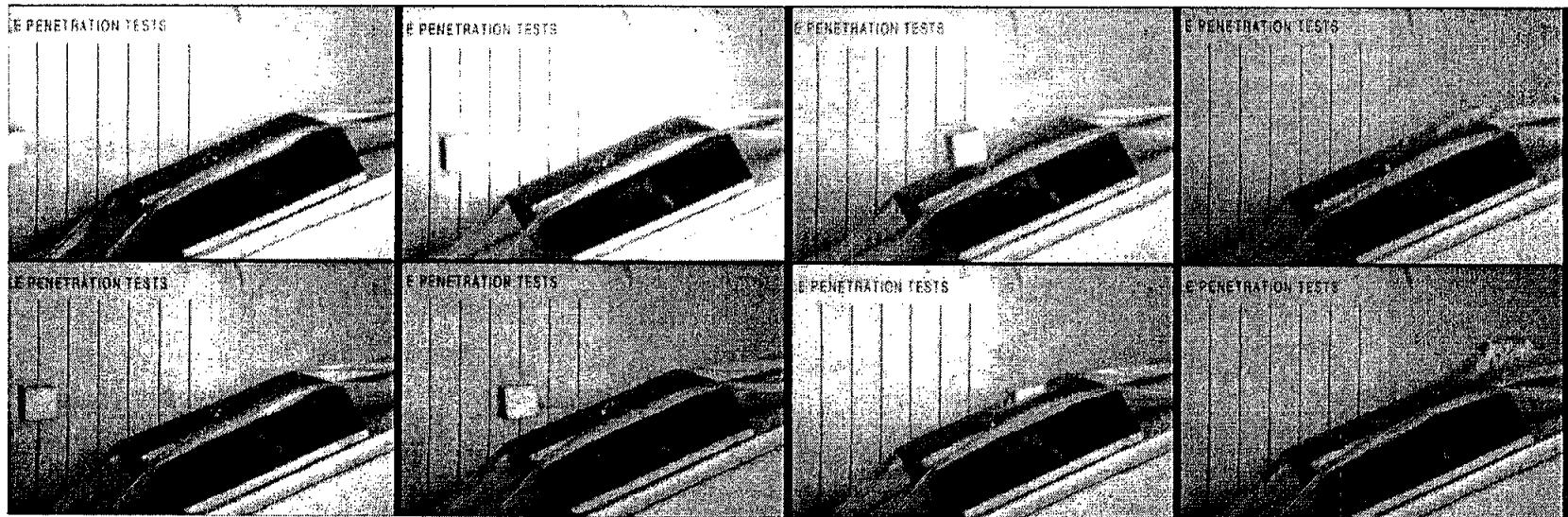
**Test No. 35**



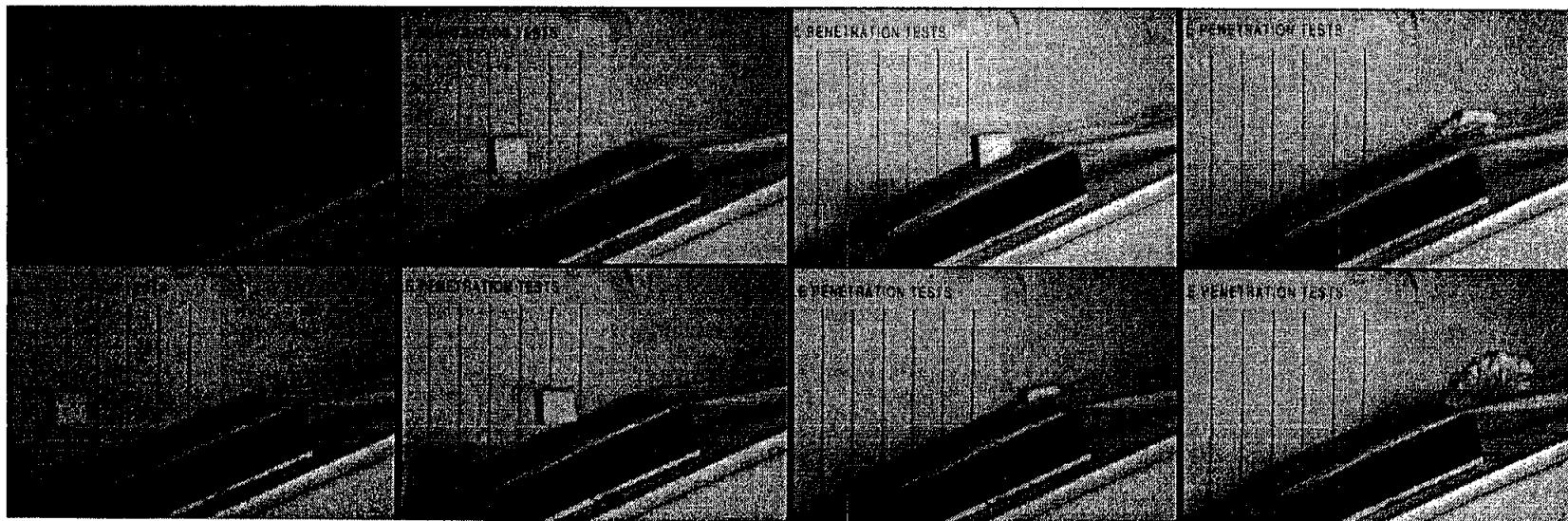
**Test No. 34A**



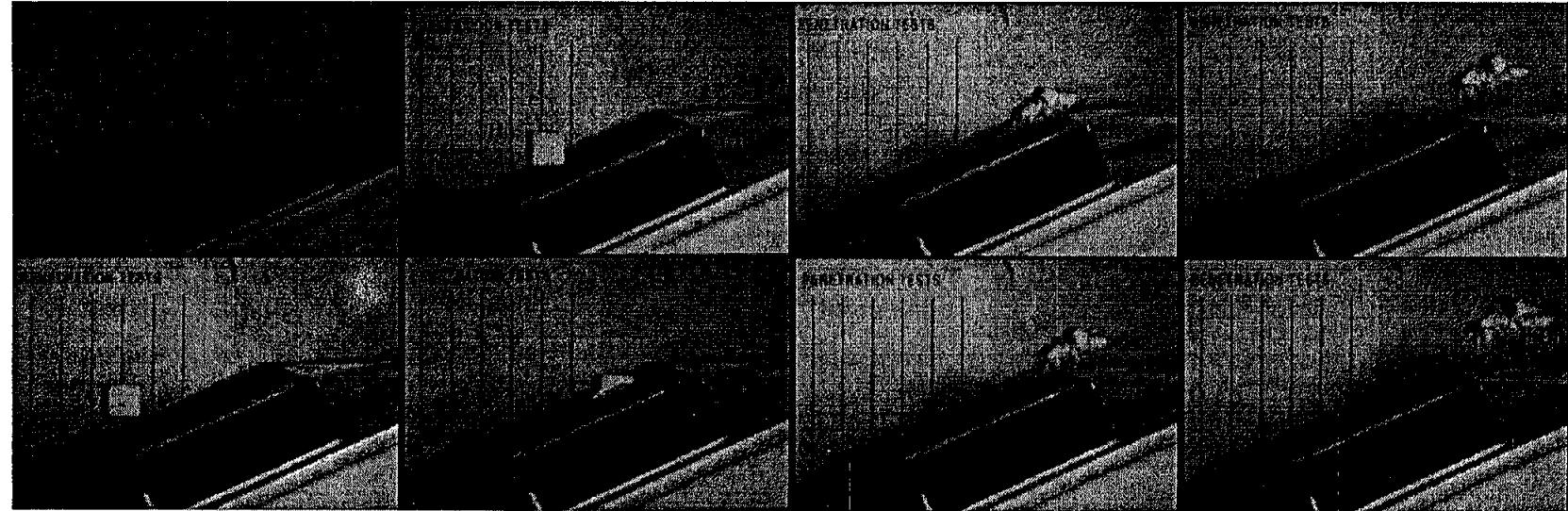
**Test No. 33**



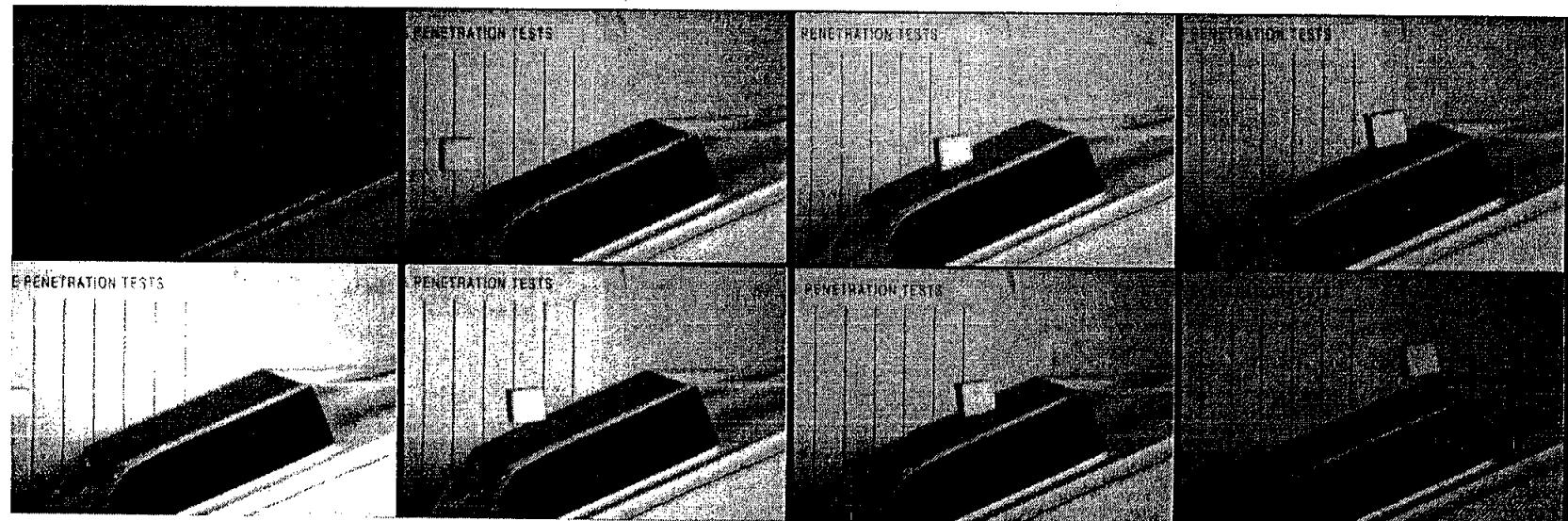
**Test No. 32**



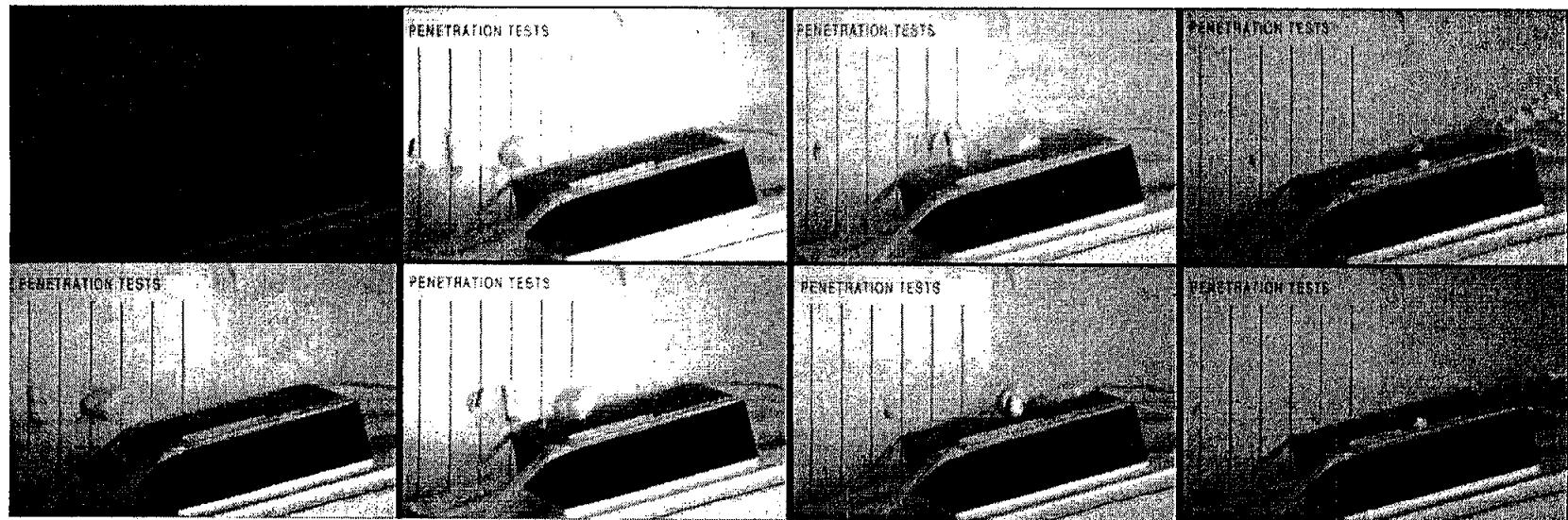
**Test No. 31**



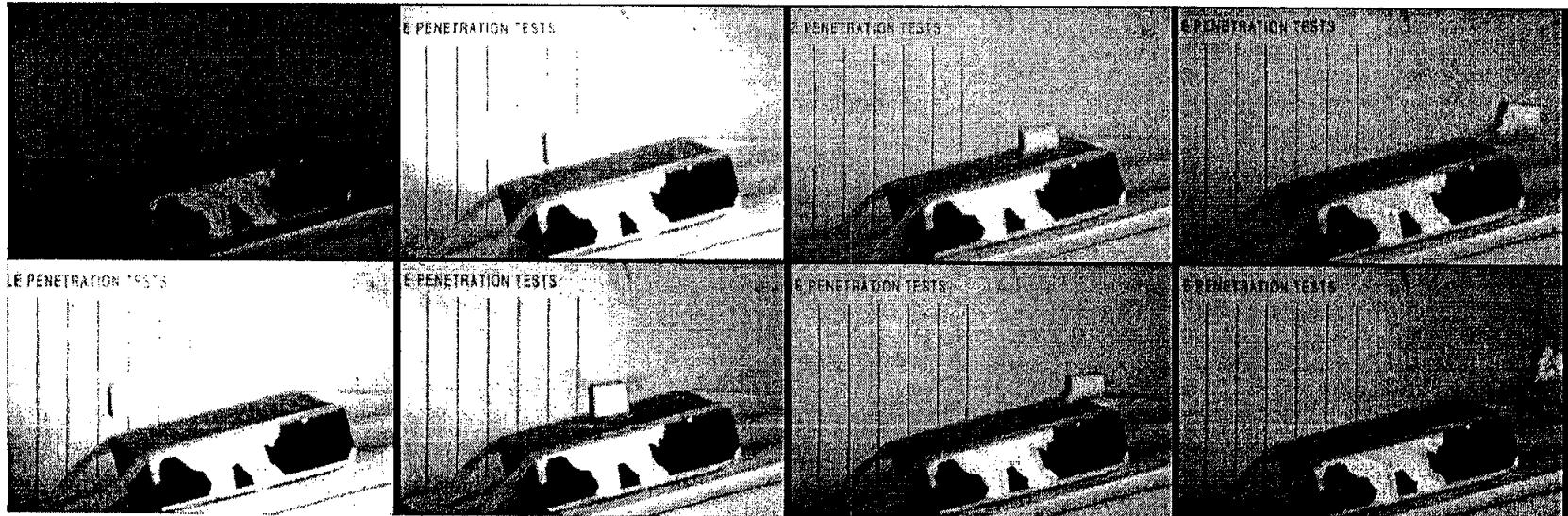
**Test No. 30**



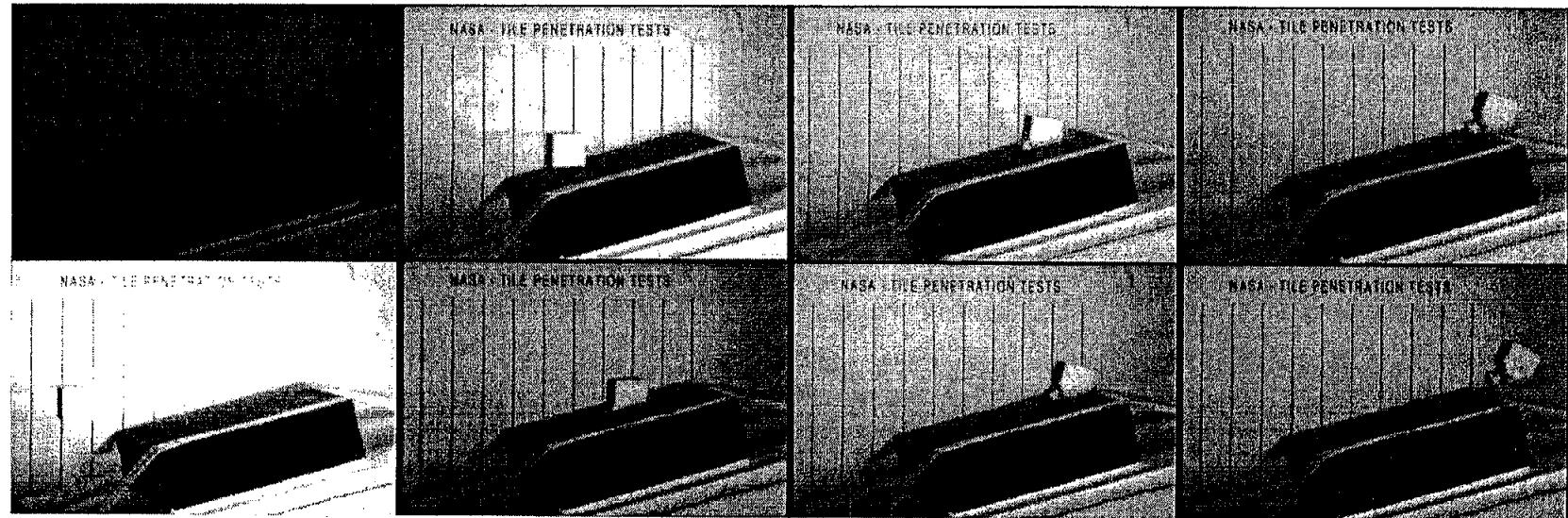
**Test No. 29**



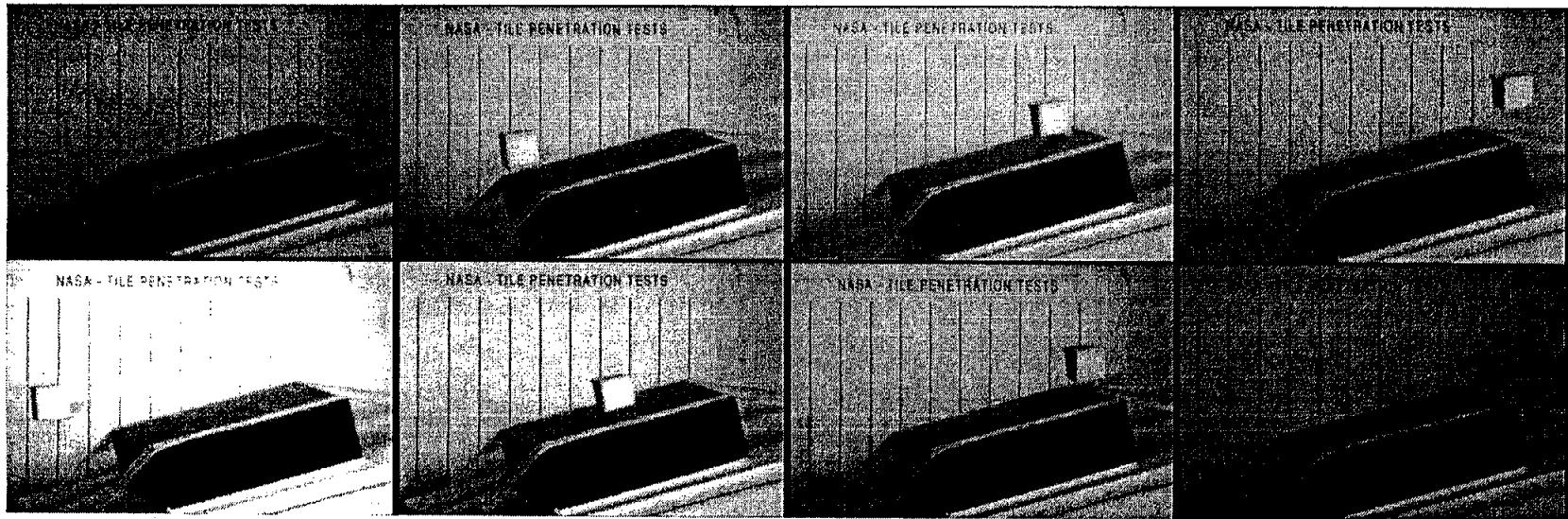
**Test No. 28B**



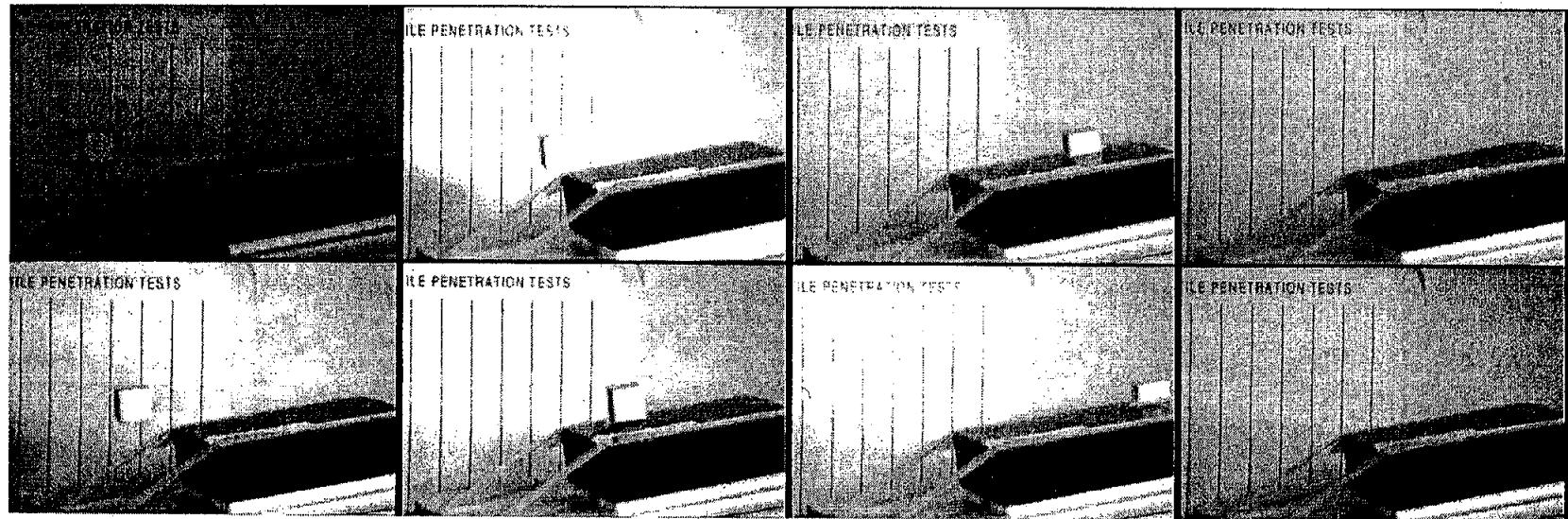
**Test No. 27**



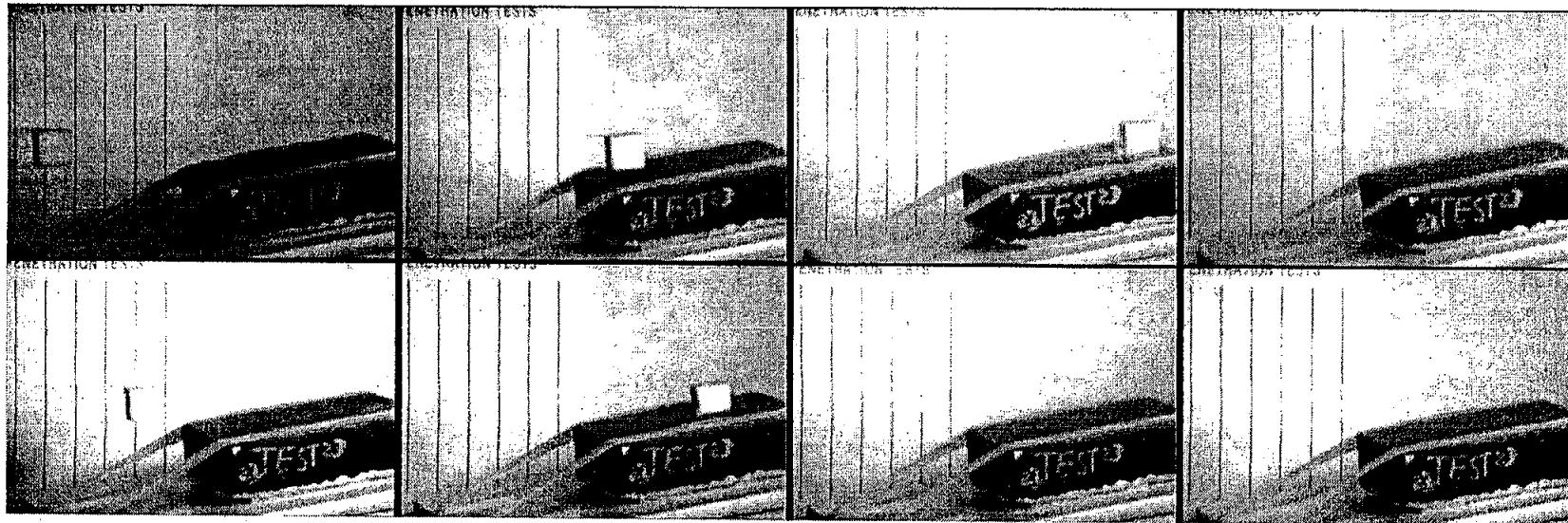
**Test No. 26**



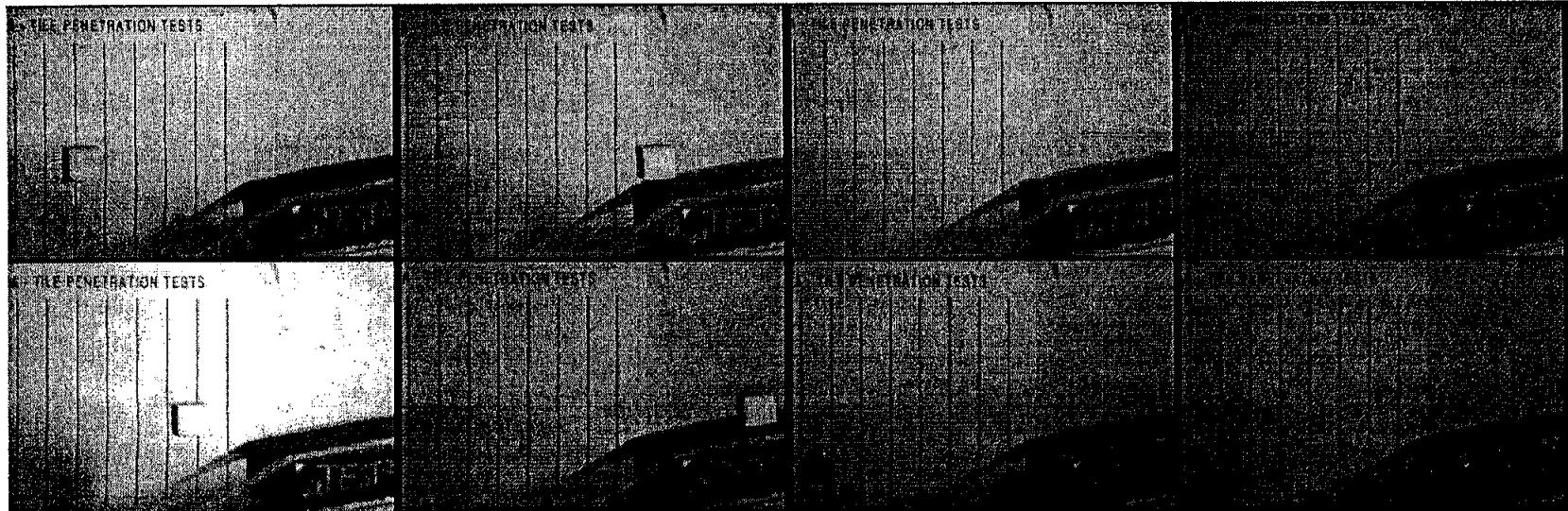
**Test No. 25**



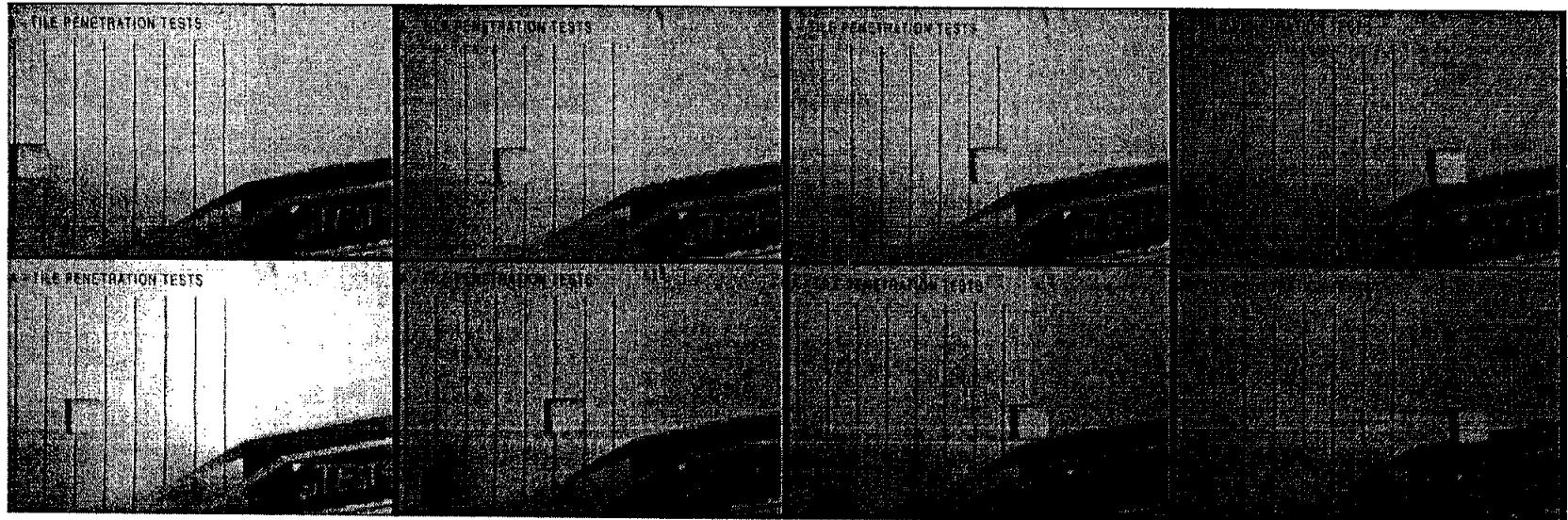
**Test No. 24F**



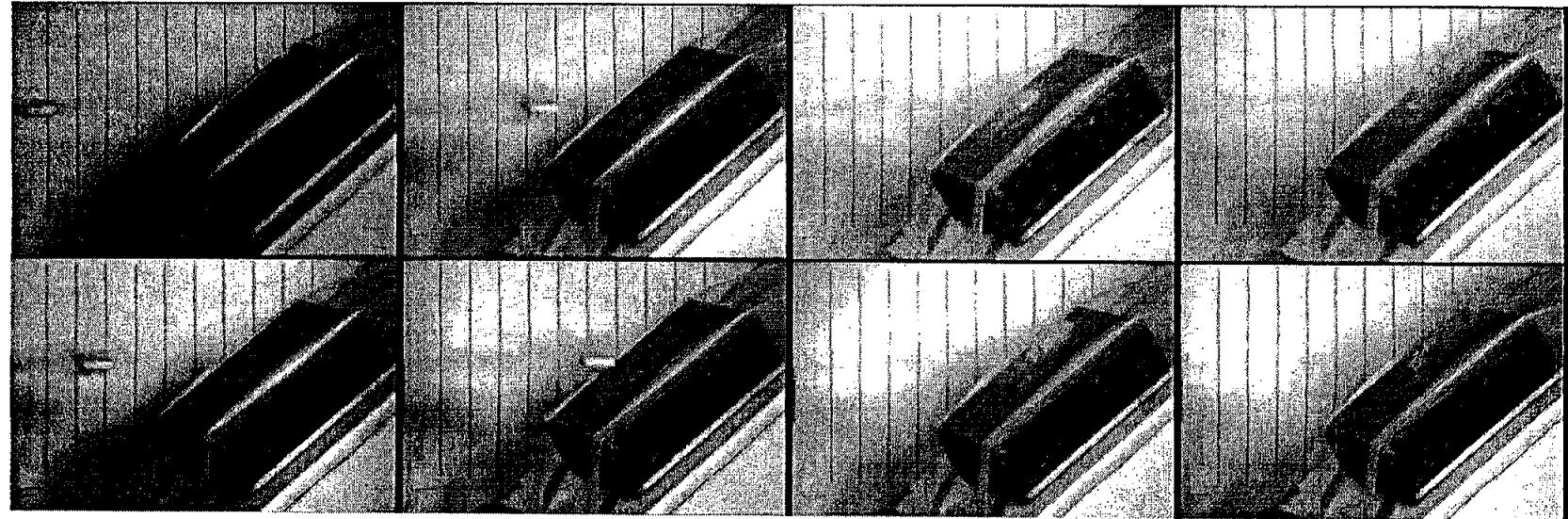
**Test No. 23**



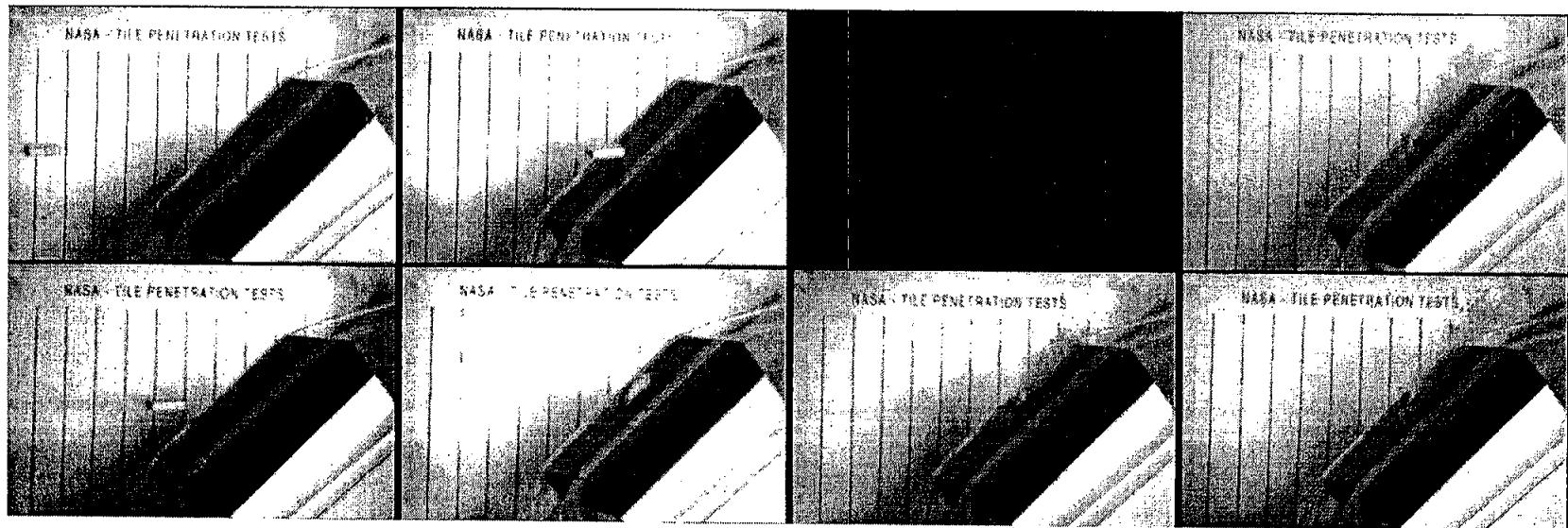
**Test No. 22**



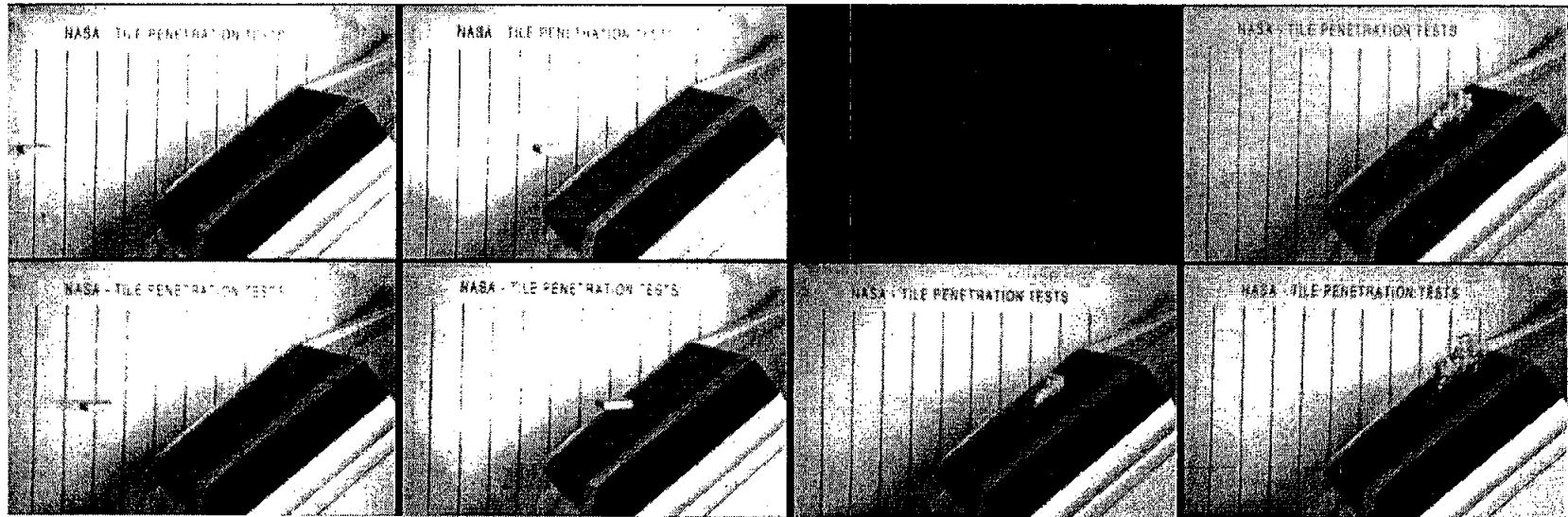
**Test No. 21**



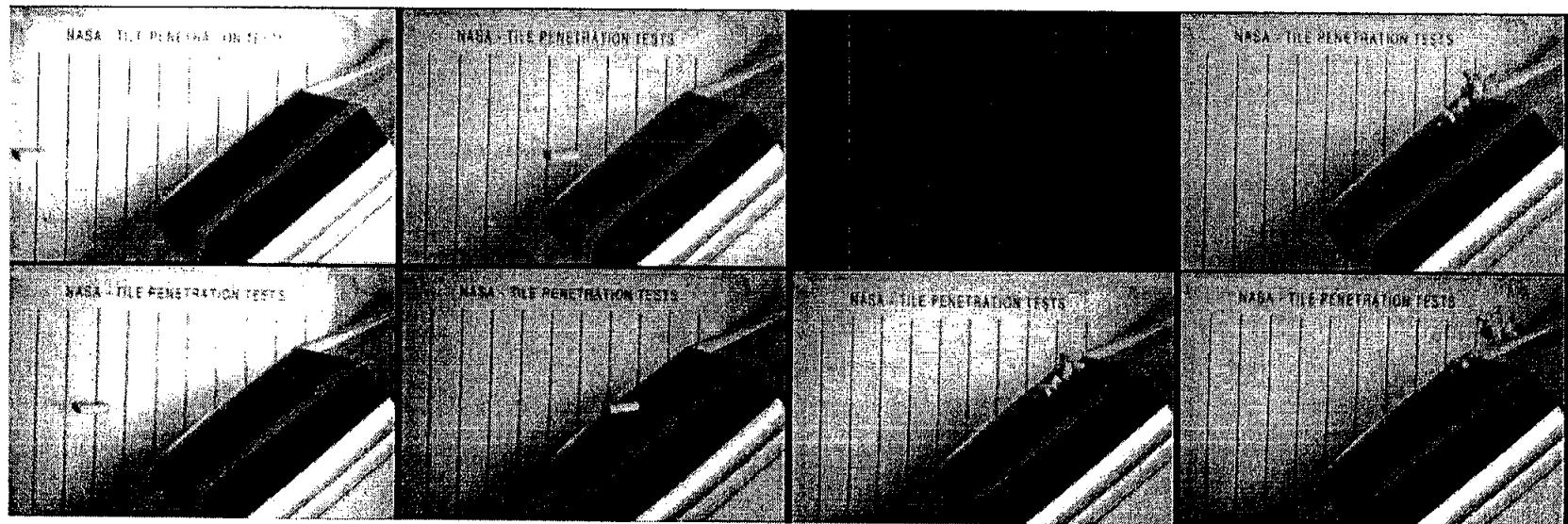
**Test No. 20F**



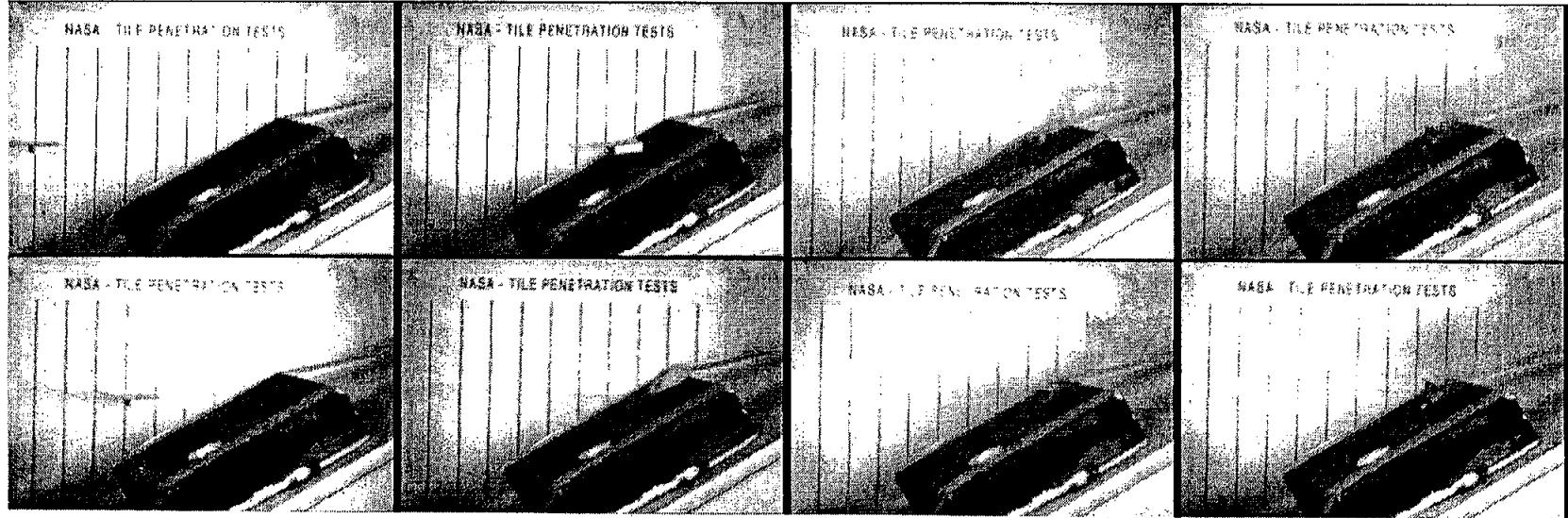
**Test No. 19D**



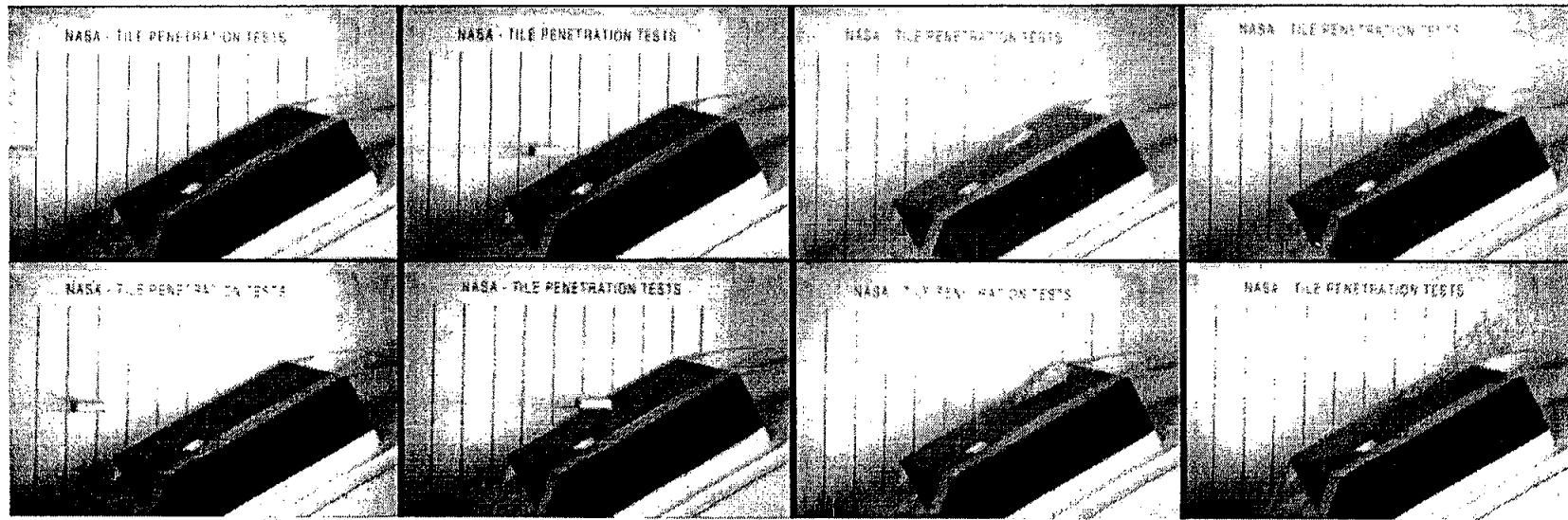
**Test No. 18**



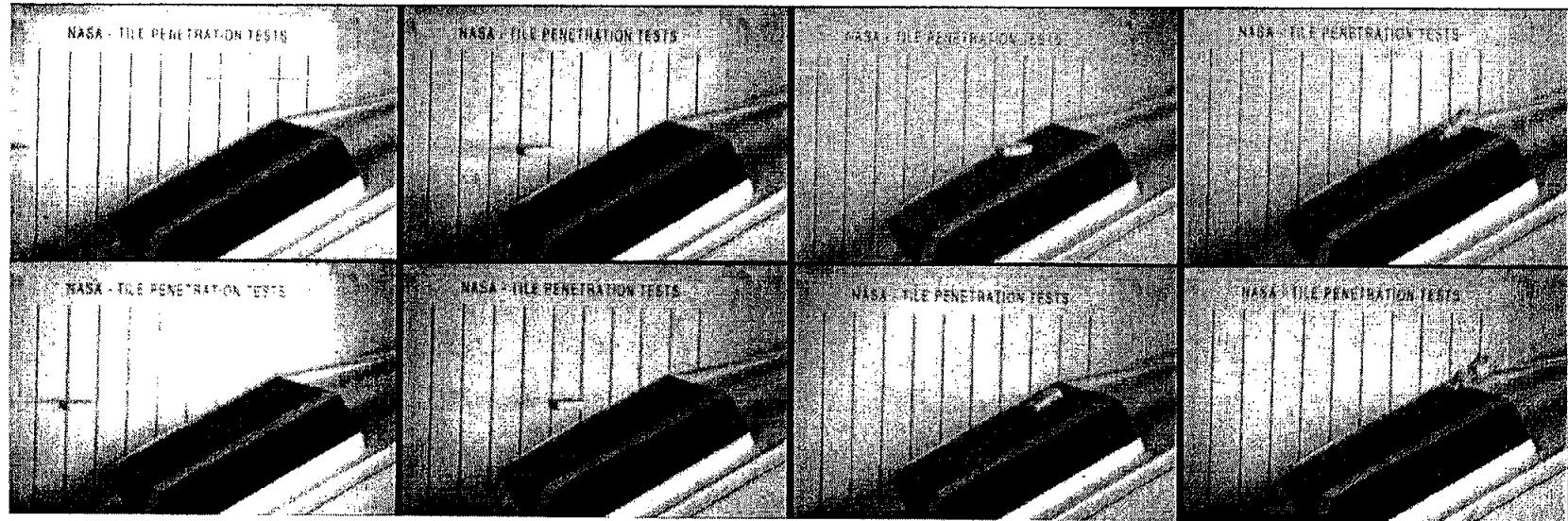
**Test No. 17**



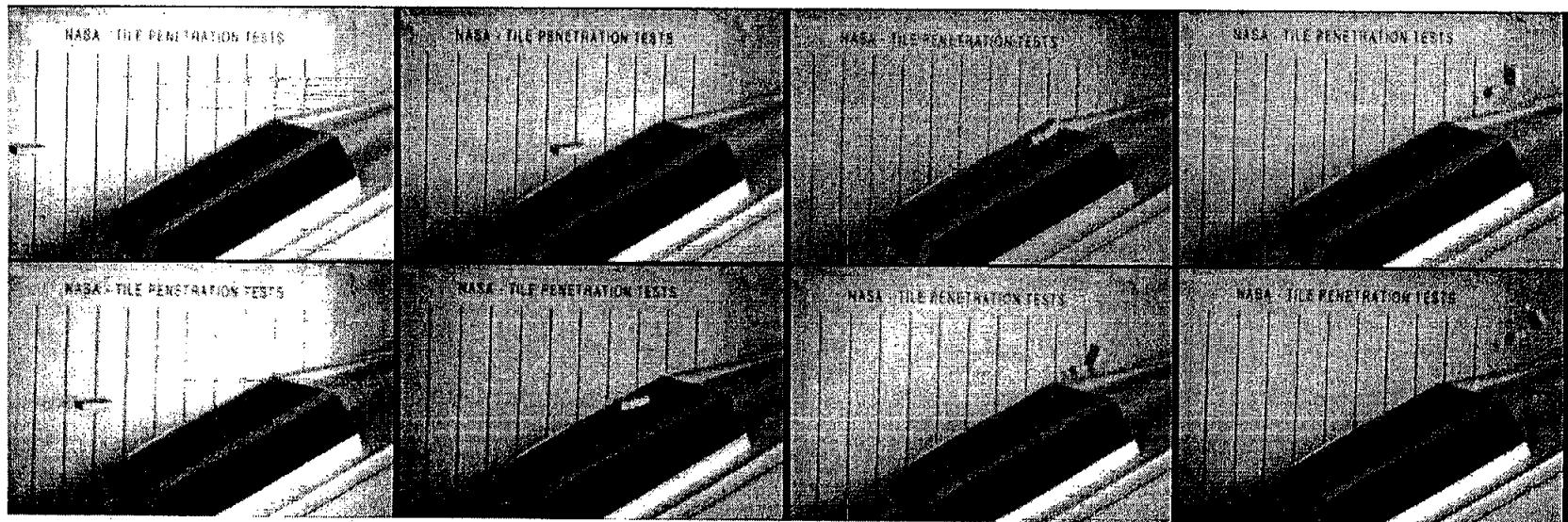
**Test No. 16B**



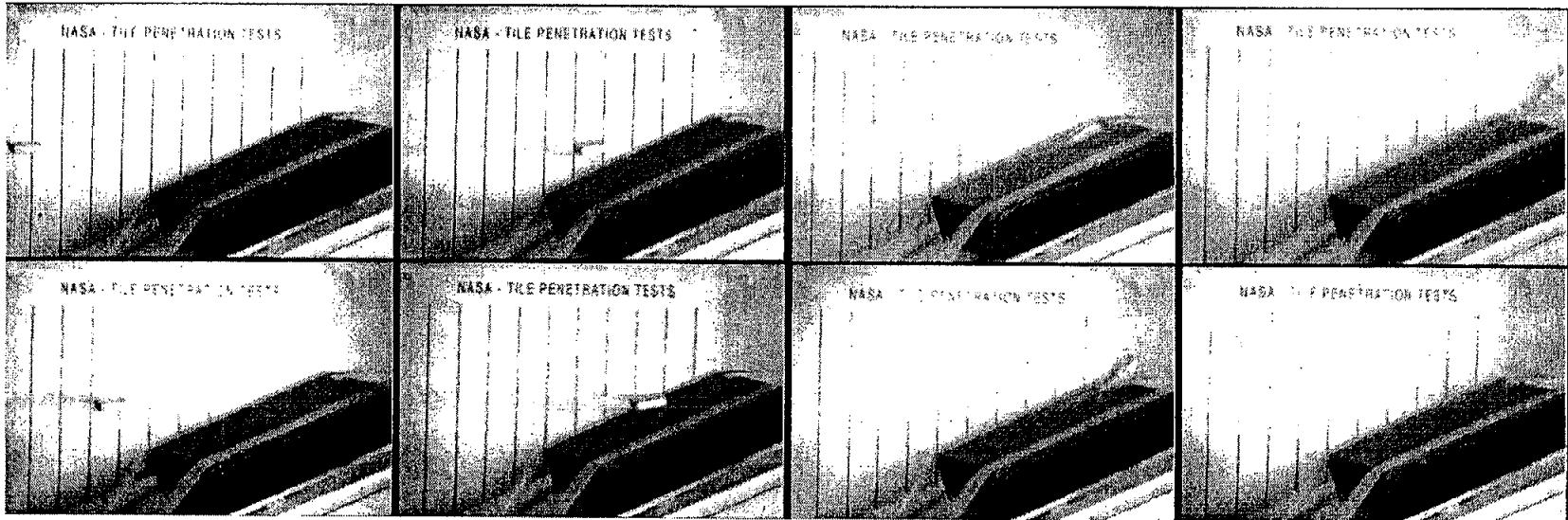
**Test No. 15**



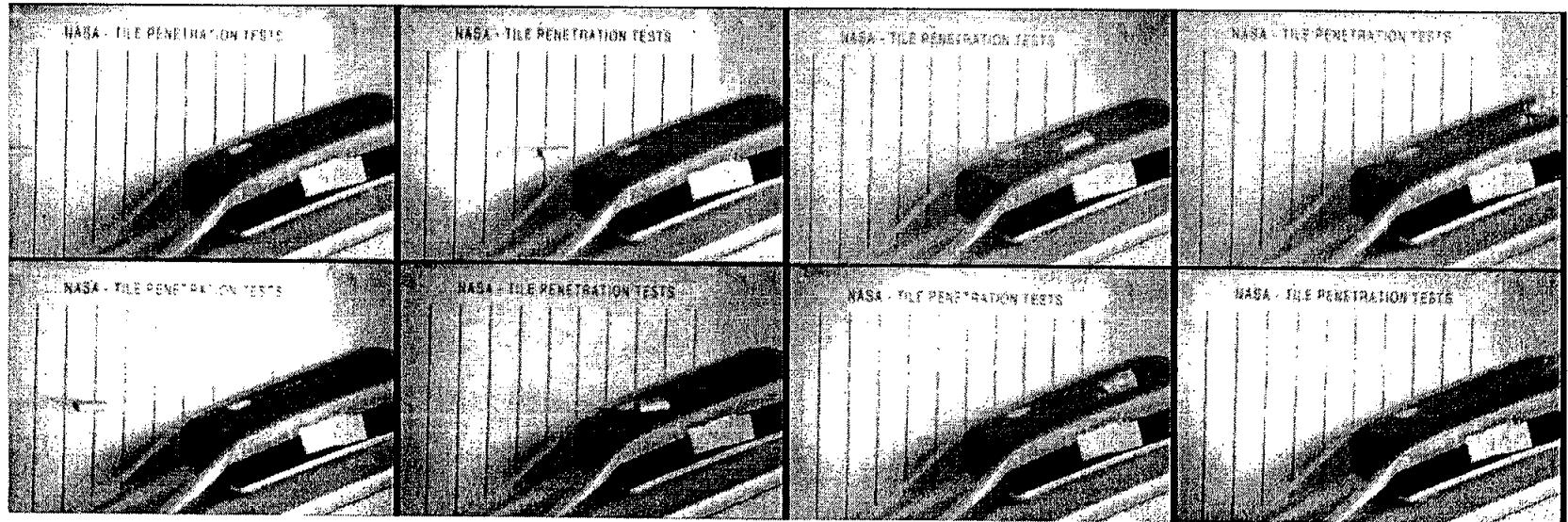
Test No. 14



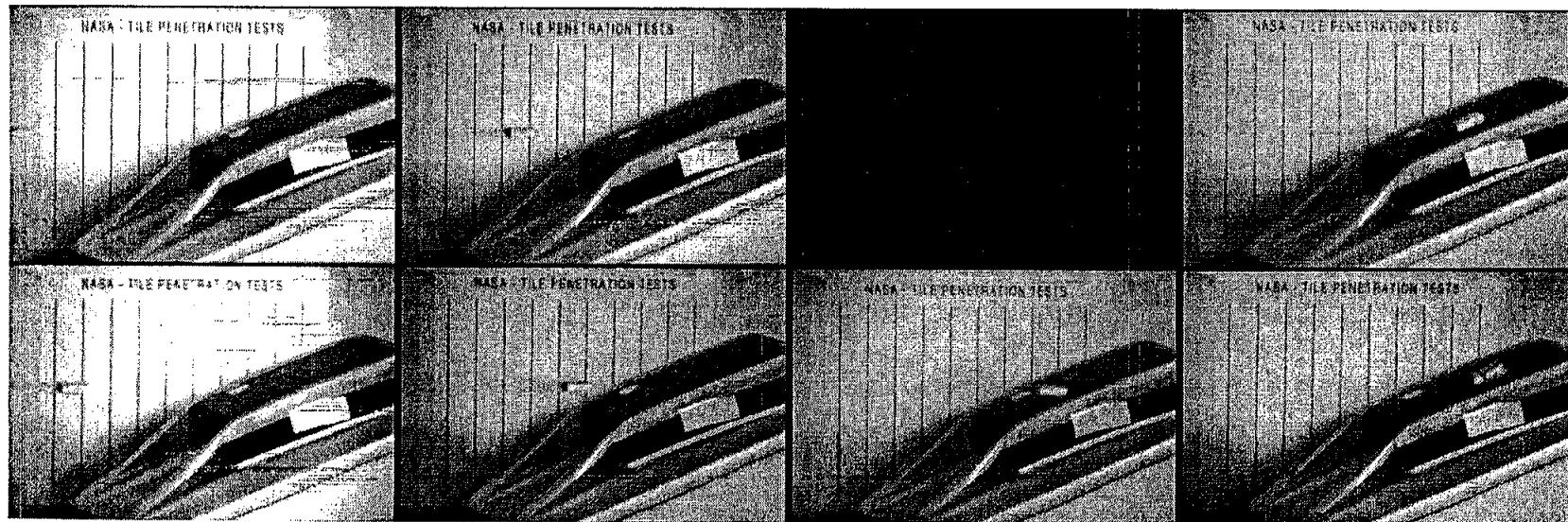
**Test No. 13**



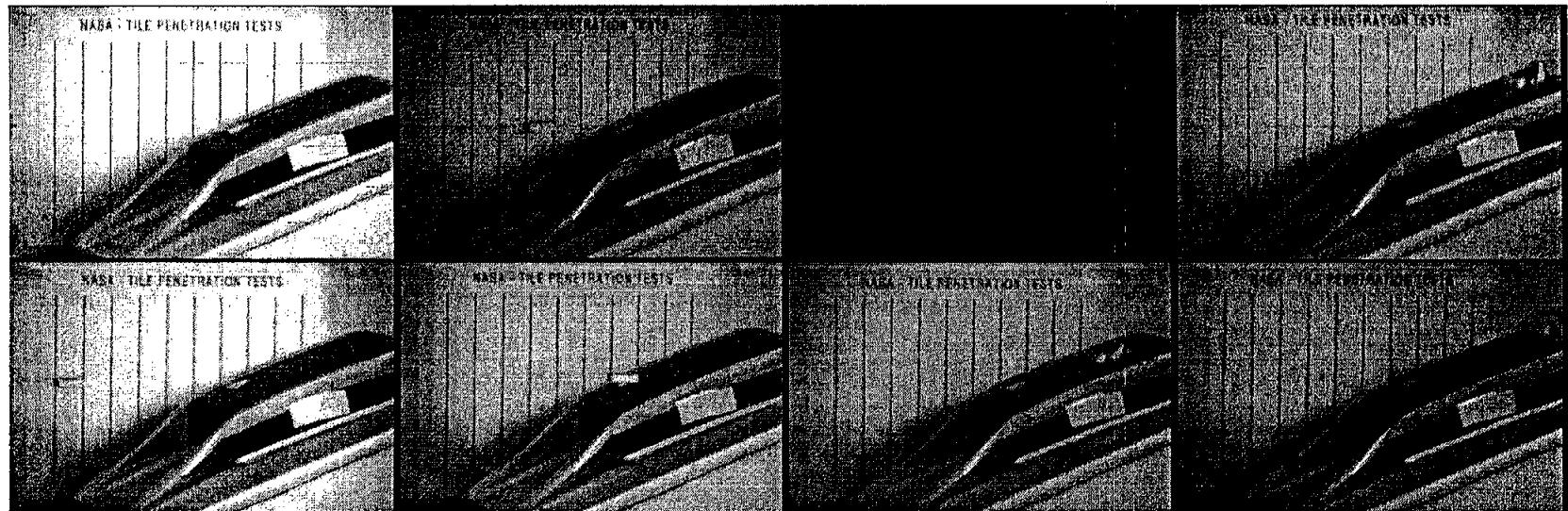
**Test No. 12**



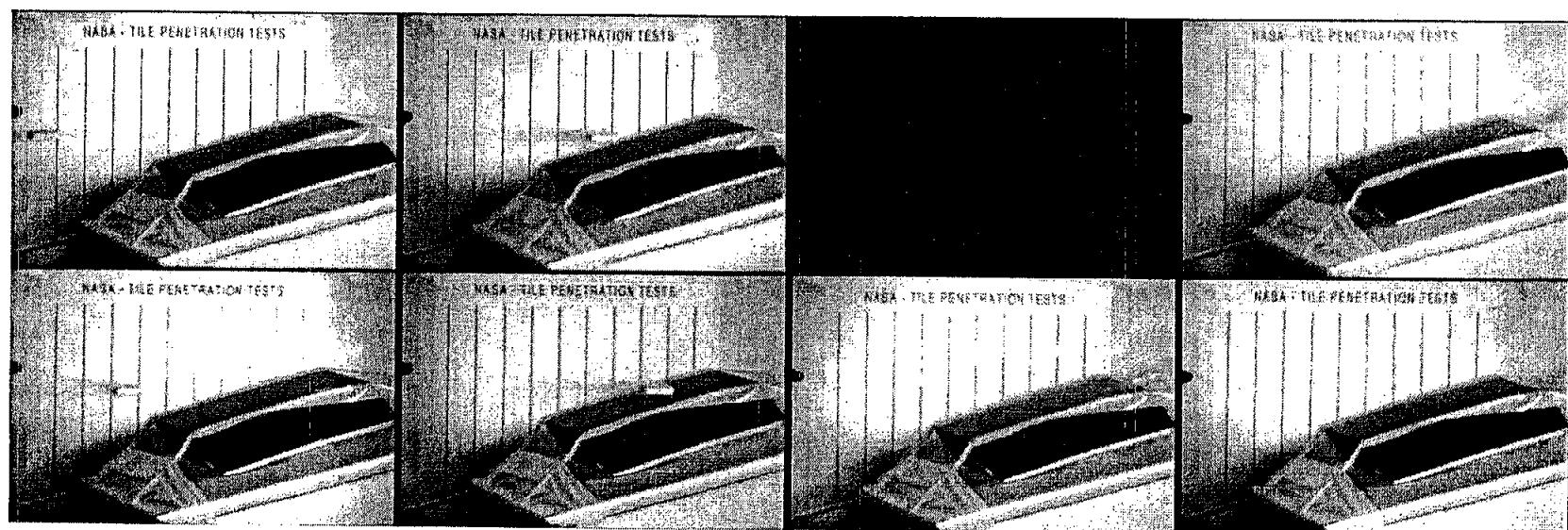
**Test No. 11**



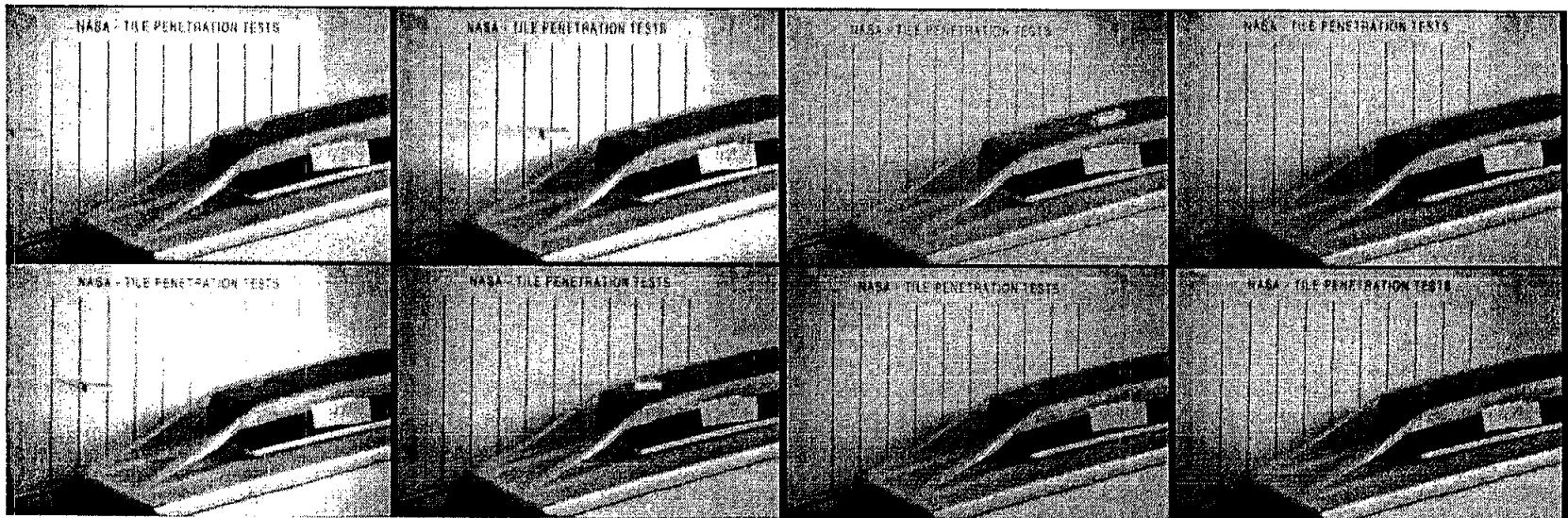
**Test No. 10**



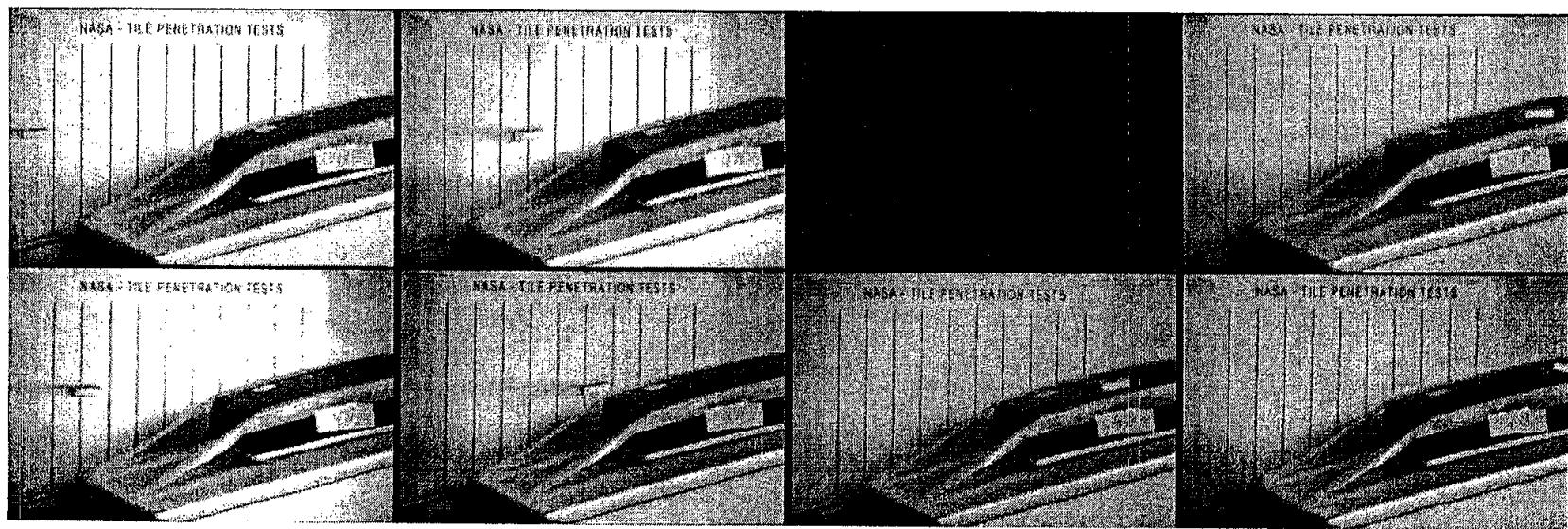
**Test No. 9**



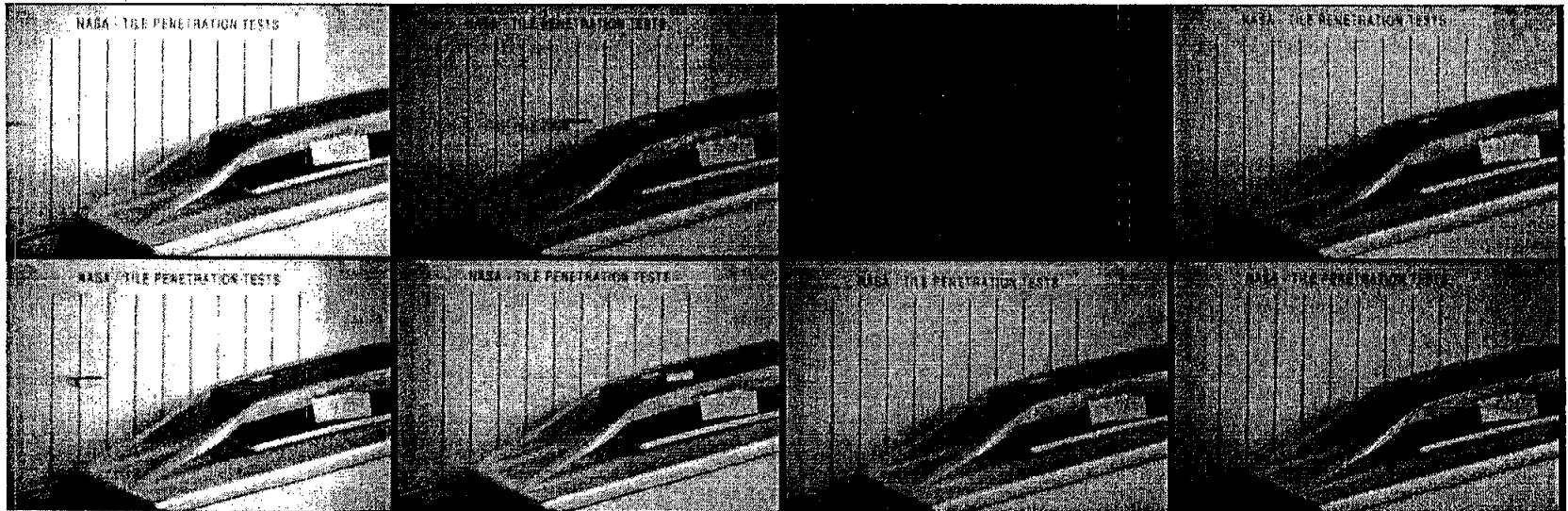
**Test No. 8**



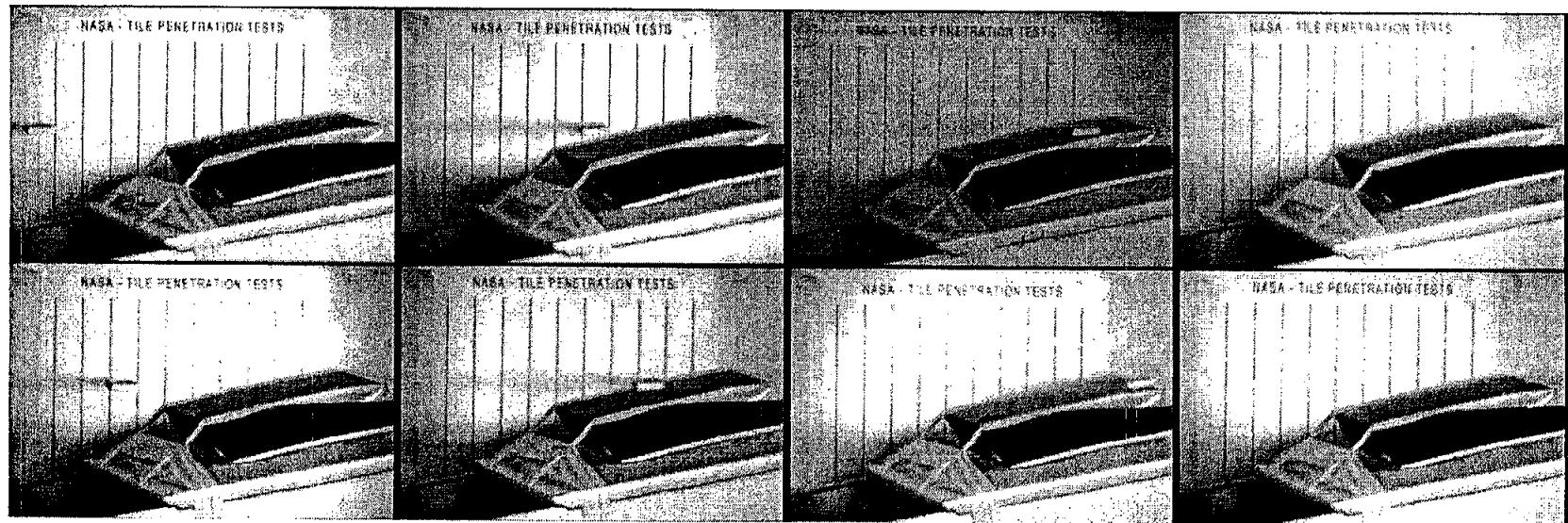
**Test No. 7**



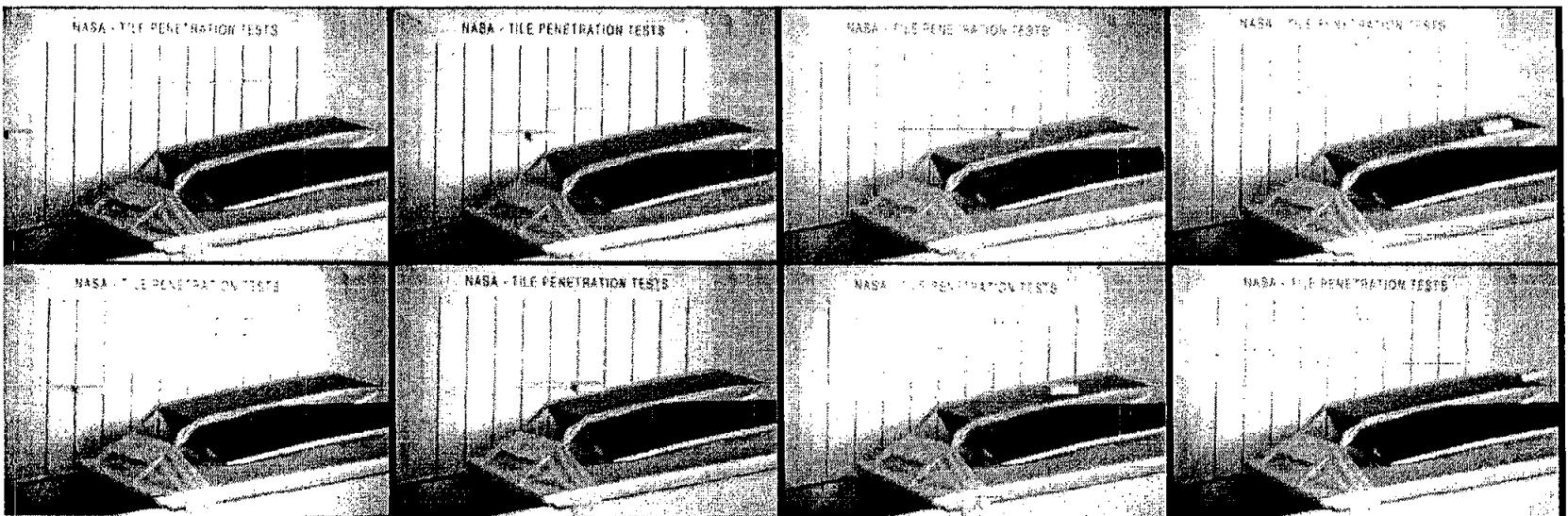
**Test No. 6**



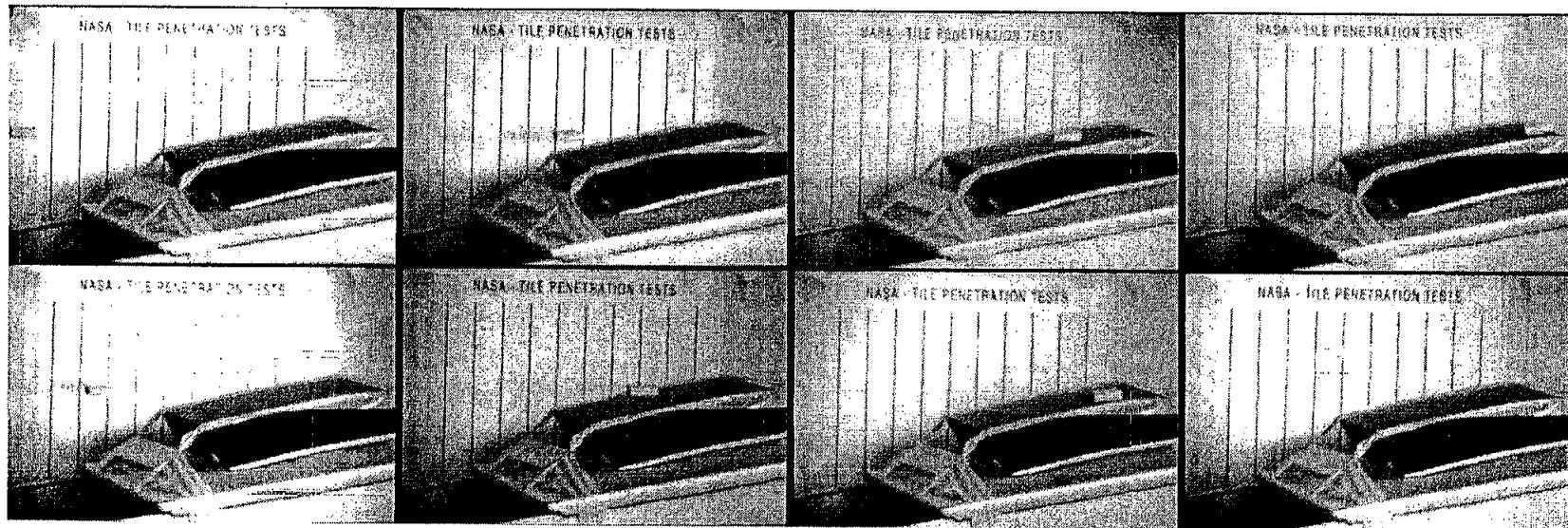
**Test No. 5**



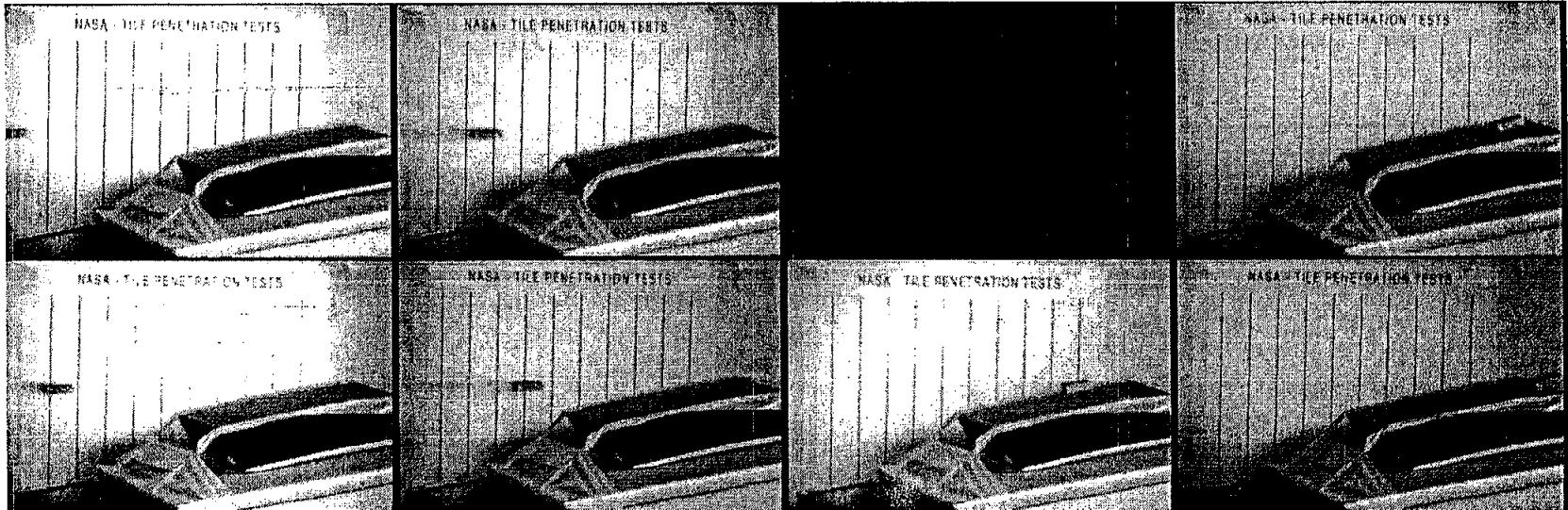
**Test No. 4B**



**Test No. 3**



**Test No. 2**



Test No. 1

## Orbiter Tile Impact Testing

### Results of All Tests (Total of 131 Tests)

Test No.	Projectile	Velocity	Impact Angle	Damage	Damage Type	Damage Max. Dimensions (Length x Wide x Depth)	Comments	Damage Volume
								cubic inches
85	1" x 1" x 3"	980	10	No	****	****	Velocity (+180 fps)	****
86	1" x 1" x 3"	1577	10	Yes	Shallow Crater, Loss of Coating	"2.56" x 1.7" x 0.11"	Velocity (-23 fps)	0.13
89	.89" x .89" x .25"	785	23	No	****	****	Velocity (-15 fps)	****
90	.89" x .89" x .25"	1400	23	Yes	Crater	0.9" x 1.2" x 0.15"	Too Slow Velocity	0.02
90A	.89" x .89" x .25"	1315	23	Yes	Crater	0.67" x 0.95" x 0.13"	Too Slow Velocity	0.04
*90B	.89" x .89" x .25"	1640	23	Yes	Shallow Crater, loss of Coating	1.1" x 1.15" x 0.11"	Velocity (+40 fps)	0.03
91	1" x 1" x 1"	794	23	Yes	Crater	1.7" x 1.21" x 0.24"	Velocity (-6 fps)	0.17
92	1" x 1" x 1"	1596	23	Yes	Crater	3.35" x 1.4" x 0.40"	Vel. (-4 fps), Proj. Slightly Broken Up	0.67
93	1" x 1" x 3"	870	23	Yes	Crater	2.25" x 1.32" x 0.27"	Velocity (+70 fps)	0.37
94	1" x 1" x 3"	~1300	23	Yes	Crater	3.45" x 2.66" x 0.30"	Projectile Broke Up	0.39
*94A	1" x 1" x 3"	1520	23	Yes	Crater	"5.02" x 1.61" x 0.65"	Velocity (-80 fps), Slightly Cracked Proj.	2.02
97	3/8" dia. X 1"	1000	60	Yes	Crater	0.53" dia. X 0.35" deep	Velocity (-9 fps), This is the New Test 97	0.05
98	3/8" dia. X 1"	1803	30	Yes	Crater	1.0" x 0.53" x 0.3"	Too Fast Velocity, New Test 98	0.09
*98A	3/8" dia. X 1"	1692	30	Yes	Crater	1.07" x 0.56" x 0.36"	Velocity (+72 fps), New Test 98A	0.10
99	3/8" dia. X 1"	-900	60	Yes	Crater	0.6" dia. X 0.32" deep	No Imacon, Guess on Velocity, New Test 99	0.03
99A	3/8" dia. X 1"	866	60	Yes	Crater	0.58" dia. X 0.35" deep	Too Fast Velocity, New Test 99A	0.04
*99B	3/8" dia. X 1"	730	60	Yes	Crater	0.62" dia. x 0.15" deep	Velocity (-5 fps), This is the New Test 99B	0.02
100	3/8" dia. X 1"	929	30	No	****	****	Test No. 97 in NoteBook, Vel (-31 fps)	****
101	3/8" dia. X 3"	1567	30	Yes	Crater	2.09" x 0.87" x 0.58"	Projectile Broke Up, New Test 101	0.27
101A	3/8" dia. X 3"	1400	30	Yes	Crater	1.6" x 0.8" x 0.58"	Too Fast Velocity, New Test 101A	0.24
*101B	3/8" dia. X 3"	1317	30	Yes	Crater	1.85" x 1.08" x 0.5"	Velocity (+111 fps), New Test 101B	0.18
102	3/8" dia. X 3"	1317	30	Yes	Crater	1.85" x 1.08" x 0.5"	Velocity (+111 fps), New Test 101B	0.18
103	3/8" dia. X 3"	1071	30	Yes	Crater	1.5" x 1.0" x 0.5"	Velocity (+46 fps), New Test 103	0.17
104	3/8" dia. X 3"	1250	60	Yes	Crater	1.01" dia. X 0.9" deep	Velocity (+50 fps), New Test 104, Proj. Slightly Broekn Up	0.15
Tuff-1	1" x 1" x 3"	~1432	40	Yes	Crater	1.5" dia. X .013" deep	No Imacon, Guess on Velocity	****
Tuff-2	1" x 1" x 1"	1575	30	Yes	Delamination of Coating	2.5" x 1.5"	Projectile Slightly Broken Up	****

\* Official Test Results for Test Matrix Test No.

\*\* Crater Extended to Tile Edge

## Orbiter Tile Impact Testing

### Results of All Tests (Total of 131 Tests)

Test No.	Projectile Type	Velocity (fps)	Impact Angle (degrees)	Damage (Yes or No)	Damage Type	Damage Max. Dimensions (Length x Wide x Depth)	Comments		Damage Volume cubic inches
43	1" x 1" x 3"	1242	10	Yes	Very Slight Cracking at Impact site	*****	Velocity (+42 fps)		*****
44	1" x 1" x 3"	1620	10	Yes	Very Slight Cracking at Tile edge	*****	Velocity (+20 fps), Projectile Slightly Broken Up		*****
45	1" x 1" x 3"	399	15	No	*****	*****	Velocity (- 1 fps)		*****
46	1" x 1" x 3"	853	15	No	*****	*****	Velocity (+53 fps)		*****
47	1" x 1" x 3"	1451	15	Yes	Crater	"3.1" x 1.3" x 0.5"	Too Fast Velocity		0.81
*47A	1" x 1" x 3"	1122	15	Yes	Delamination and Cracking of Coating	1.5" x 1.0"	Velocity (-78 fps)		*****
48	1" x 1" x 3"	1273	15	Yes	Delam. Cracking, Loss of Coating	1.5" dia.	Too Slow Velocity		0.05
48A	1" x 1" x 3"	~1500	15	Yes	Crater	4.0" x 1.3" x 0.4"	No Imacon, Guess on Velocity		1.00
48B	1" x 1" x 3"	~1500	15	Yes	Slight Cracking of Tile Edge	*****	No Imacon, Guess on Velocity		*****
*48C	1" x 1" x 3"	1526	15	Yes	Crater	"3.35" x 1.25" x 0.5"	Velocity (-74 fps), Extended to Tile Edge		0.86
49	1" x 1" x 3"	440	23	No	*****	*****	Velocity (+40 fps)		*****
50	1" x 1" x 3"	920	23	Yes	Crater	1.66" x 1.36" x 0.15"	Too Fast Velocity		0.09
*50A	1" x 1" x 3"	723	23	Yes	Crater	1.8" x 1.1" x 0.2"	Velocity (-87 fps)		0.29
51	1" x 1" x 3"	~1350	23	Yes	Crater	4.0" x 1.1" x 0.71"	No Imacon, Guess on Velocity		2.18
51A	1" x 1" x 3"	~1350	23	Yes	Crater	"4.0 x 1.25" x 0.55"	No Imacon, Guess on Velocity		1.90
*51B	1" x 1" x 3"	1356	23	Yes	Crater	"4.25" x 1.3" x 0.63"	Velocity (+156 fps), Extended To Tile Edge		2.51
52	1" x 1" x 3"	~1400	23	Yes	Crater	4.4" x 2.0" x 0.30"	No Imacon, Guess on Velocity		0.46
52A	1" x 1" x 3"	1350	23	Yes	Crater	4.75" x 2.0" x 0.35"	Too Slow Velocity		0.98
*52B	1" x 1" x 3"	1588	23	Yes	Crater	"4.0" x 1.1" x 0.8"	Velocity (-12 fps), Extended to Tile Edge		2.59
53	1" x 1" x 3"	410	30	No	*****	*****	Velocity (+10 fps)		*****
54	1" x 1" x 3"	803	30	Yes	Crater	2.0" x 1.25" x 0.08"	Velocity (+3 fps)		0.17
55	1" x 1" x 3"	1161	30	Yes	Crater	"3.65" x 1.5" x .75"	Velocity (-39 fps), Extended to Tile Edge		2.01
56	1" x 1" x 3"	1386	30	Yes	Crater	4.13" x 2.75" x 0.6"	Velocity (-214 fps), Projectile Slightly Broken Up		1.83
57	1" x 1" x 3"	-400	30	No	*****	*****	No Imacon, Guess on Velocity		*****
*57A	1" x 1" x 3"	467	40	Yes	Delamination and Cracking of Coating	0.75" diameter x 0.13" deep	Velocity (+67 fps)		0.01
58	1" x 1" x 3"	801	40	Yes	Crater	2.5" x 1.2" x 0.4"	Velocity (+1 fps)		0.76
59	1" x 1" x 3"	~1200	40	Yes	Crater	"4.0" x 3.0" x 2.0"	No Imacon, Guess on Velocity		*****
*59A	1" x 1" x 3"	1126	40	Yes	Crater	4.5" x 2.0" x 1.0"	Velocity (-74 fps)		2.30
60	1" x 1" x 3"	1432	40	Yes	Crater	"6.0" x 3.0" x 2.0"	Velocity (-168 fps), Projectile Broke Up		*****
81	.89" x .89" x .25"	750	10	No	*****	*****	Velocity (-50 fps)		*****
82	.89" x .89" x .25"	1553	10	No	*****	*****	Velocity (-47 fps)		*****
83	1" x 1" x 1"	790	10	No	*****	*****	Velocity (-10 fps)		*****
84	1" x 1" x 1"	1425	10	No	*****	*****	Projectile Broke Up		*****
84A	1" x 1" x 1"	1464	10	No	*****	*****	Projectile Broke Up		*****
*84B	1" x 1" x 1"	1710	10	Yes	Shallow Crater, loss of Coating	"2.25" x 1.63" x 0.10"	Velocity (+110)		0.08

## Orbiter Tile Impact Testing

### Results of All Tests (Total of 131 Tests)

Test No.	Projectile	Velocity	Impact Angle	Damage	Damage Type	Damage Max. Dimensions (Length x Wide x Depth)	Comments		Damage Volume cubic inches
							Type	(fps)	
21	1" x 1" x 1"	338	10	No	****	****	Velocity (-62 fps)		****
22	1" x 1" x 1"	670	10	No	****	****	Velocity (-130 fps)		****
23	1" x 1" x 1"	1147	10	Yes	Coating Cracking	one small crack	Velocity (-53 fps)		****
24	1" x 1" x 1"	1108	10	Yes	Delamination and Cracking of Coating	1.5" x 1.4"	Too Slow Velocity		****
24B	1" x 1" x 1"	1317	10	Yes	Delam., Cracking, Loss of Coating	1.0" x 1.25"	Too Slow Velocity, No 24A Test		0.04
24C	1" x 1" x 1"	1548	10	Yes	Delamination and Cracking of Coating	****	Projectile Broke Up		****
24D	1" x 1" x 1"	-1500	10	Yes	Delamination and Cracking of Coating	****	No Imacon, Guess on Velocity		****
24E	1" x 1" x 1"	-1400	10	Yes	Shallow Crater	3.0" x 1.5"	No Imacon, Guess on Velocity		0.15
*24F	1" x 1" x 1"	1788	10	Yes	Shallow Crater, Loss of Coating	2.0" x 2.5"	Velocity (+188 fps)		0.11
25	1" x 1" x 1"	490	15	No	****	****	Velocity (+90 fps)		****
26	1" x 1" x 1"	-800	15	Yes	Delamination and Cracking of Coating	1.25" Diameter	No Imacon, Guess on Velocity		****
*26A	1" x 1" x 1"	856	15	No	****	****	Velocity (+56 fps)		****
27	1" x 1" x 1"	1221	15	Yes	Shallow Crater, Loss of Coating	1.25" x 2.5" x 0.1"	Velocity (+21 fps)		0.11
28	1" x 1" x 1"	1556	15	Yes	Star Crack at Impact Site	****	Projectile Broke Up		****
28A	1" x 1" x 1"	1365	15	Yes	Delamination and Cracking of Coating	1.0" x 3.0"	Too Slow Velocity		****
*28B	1" x 1" x 1"	1465	15	Yes	Shallow Crater, Loss of Coating	2.0" x 2.0" x 0.1"	Velocity (-135 fps), Projectile Slightly Broken Up		0.10
29	1" x 1" x 1"	353	23	No	****	****	Velocity (-47 fps)		****
30	1" x 1" x 1"	-800	23	Yes	Delamination of Coating	1.0" x 1.0"	No Imacon, Guess on Velocity		****
30A	1" x 1" x 1"	-800	23	Yes	Very Small Crack	1.0" Long	No Imacon, Guess on Velocity		****
*30B	1" x 1" x 1"	934	23	Yes	Shallow Crater, Loss of Coating	1.0" x 2.0" x 0.1"	Velocity (+134 fps)		0.05
31	1" x 1" x 1"	1233	23	Yes	Crater	**1.25" x 2.25" x 0.25"	Velocity (+33 fps)		0.34
32	1" x 1" x 1"	1557	23	Yes	Crater	3.75" x 1.5" x 0.4"	Velocity (-43 fps)		0.64
33	1" x 1" x 1"	452	30	No	****	****	Velocity (+52 fps)		****
34	1" x 1" x 1"	-800	30	Yes	Shallow Crater, Loss of Coating	2.25" x 1.3" x 0.1"	No Imacon, Guess on Velocity		0.05
*34A	1" x 1" x 1"	805	30	Yes	Crater	2.0" x 1.25" x 0.25"	Velocity (+5 fps)		0.13
35	1" x 1" x 1"	1240	30	Yes	Crater	2.25" x 1.38" x 0.4"	Velocity (+40 fps), Projectile Cracked		0.47
36	1" x 1" x 1"	-1500	30	Yes	Crater	3.0" x 1.0" x 0.50"	No Imacon, Guess on Velocity		0.81
*36A	1" x 1" x 1"	1483	30	Yes	Crater	2.5" x 1.5" x 0.5"	Velocity (-117 fps), Projectile Slightly Broken Up		0.58
37	1" x 1" x 1"	447	40	No	****	****	Velocity (+47 fps)		****
38	1" x 1" x 1"	767	40	Yes	Crater	1.5" x 1.25" x 0.38"	Velocity (-33 fps), Projectile lost a small piece		0.21
39	1" x 1" x 1"	1216	40	Yes	Crater	2.5" x 1.1" x 0.5"	Velocity (+16 fps)		0.65
40	1" x 1" x 1"	-1450	40	Yes	Crater	2.0" x 1.5" x 0.63"	No Imacon, Guess on Velocity		0.80
*40A	1" x 1" x 1"	1616	40	Yes	Crater	3.0" x 1.5" x 0.5"	Velocity (+16 fps), Projectile Slightly Broken Up		0.61
41	1" x 1" x 3"	409	10	No	****	****	Velocity (+9 fps)		****
42	1" x 1" x 3"	809	10	No	****	****	Velocity (+9 fps)		****

## Orbiter Tile Impact Testing

### Results of All Tests (Total of 131 Tests)

Test No.	Projectile Type	Velocity (fps)	Impact Angle (degrees)	Damage (Yes or No)	Damage Type	Damage Max. Dimensions (Length x Wide x Depth)	Comments		Damage Volume cubic inches
1	.89" x .89" x .25"	441	10	No	****	****	Velocity (+41 fps)		****
2	.89" x .89" x .25"	975	10	No	****	****	Velocity (+175 fps)		****
3	.89" x .89" x .25"	1166	10	No	****	****	Velocity (-34 fps)		****
4	.89" x .89" x .25"	1124	10	No	****	****	Velocity (-476 fps)		****
4A	.89" x .89" x .25"	1340	10	No	****	****	Velocity (-260 fps)		****
*4B	.89" x .89" x .25"	1550	10	No	****	****	Velocity (-50 fps)		****
5	.89" x .89" x .25"	731	15	No	****	****	Velocity (+331 fps)		****
6	.89" x .89" x .25"	952	15	No	****	****	Velocity (+152 fps)		****
7	.89" x .89" x .25"	1279	15	No	****	****	Velocity (+79 fps)		****
8	.89" x .89" x .25"	1606	15	Yes	Delamination and Cracking of Coating	1.0" Diameter	Velocity (+6 fps),	0.02	
9	.89" x .89" x .25"	579	23	No	****	****	Velocity (+179 fps)		****
10	.89" x .89" x .25"	794	23	No	****	****	Velocity (-6 fps)		****
11	.89" x .89" x .25"	1257	23	Yes	Delamination and Cracking of Coating	0.94" Diameter	Velocity (+57 fps)		****
12	.89" x .89" x .25"	1490	23	Yes	Delam., Cracking, Loss of Coating	1.25" Diameter	Velocity (-110 fps)	0.04	
13	.89" x .89" x .25"	552	30	No	****	****	Velocity (+152 fps)		****
14	.89" x .89" x .25"	825	30	No	****	****	Velocity (+25 fps)		****
15	.89" x .89" x .25"	-1200	30	Yes	Shallow Crater, Loss of Coating	0.9" x 1.1" x 0.12"	No Imacon, Guess on Velocity	0.03	
*15A	.89" x .89" x .25"	1160	30	Yes	Shallow Crater, Loss of Coating	0.94 x 1.25" x 0.13"	Velocity (-40 fps)	0.03	
16	.89" x .89" x .25"	-1500	30	Yes	Crater	0.9" x 1.1" x 0.2"	No Imacon, Guess on Velocity	0.09	
16A	.89" x .89" x .25"	-1500	30	Yes	Crater	1.2" x 1.2" x 0.2"	No Imacon, Guess on Velocity	0.10	
*16B	.89" x .89" x .25"	1605	30	Yes	Crater	1.34" x 1.1" x 0.26"	Velocity (+5 fps)	0.13	
17	.89" x .89" x .25"	518	40	No	****	****	Velocity (+116 fps)		****
18	.89" x .89" x .25"	799	40	Yes	Delamination and Cracking of Coating	0.66" x 0.98"	Velocity (-1 fps)		****
19	.89" x .89" x .25"	-1200	40	Yes	Crater	0.8" x 1.1" x 0.23"	No Imacon, Guess on Velocity	0.06	
19A	.89" x .89" x .25"	885	40	Yes	Crater	0.9" x 1.0" x 0.2"	Too Slow Velocity	0.05	
19B	.89" x .89" x .25"	913	40	Yes	Crater	0.8" x 1.0" x 0.12"	Too Slow Velocity	0.04	
19C	.89" x .89" x .25"	953	40	Yes	Crater	1.0" x 1.2" x 0.1"	Too Slow Velocity	0.02	
*19D	.89" x .89" x .25"	1252	40	Yes	Crater	1.0" x 1.1" x 0.41"	Velocity (+52 fps)	0.19	
20	.89" x .89" x .25"	1120	40	Yes	Crater	0.9" x 1.05" x 0.35"	Too Slow Velocity	0.13	
20A	.89" x .89" x .25"	-1500	40	Yes	Crater	1.0" x 1.4" x 0.4"	No Imacon, Guess on Velocity	0.17	
20B	.89" x .89" x .25"	1074	40	Yes	Crater	1.0" x 1.2" x 0.28"	Too Slow Velocity	0.11	
20C	.89" x .89" x .25"	-1250	40	Yes	Crater	0.94" x 1.1" x 0.30"	No Imacon, Guess on Velocity	0.10	
20D	.89" x .89" x .25"	1081	40	Yes	Crater	1.0" x 1.2" x 0.25"	Too Slow Velocity	0.11	
20E	.89" x .89" x .25"	-1500	40	Yes	Crater	1.1" x 1.2" x 0.5"	No Imacon, Guess on Velocity	0.23	
*20F	.89" x .89" x .25"	1520	40	Yes	Crater	1.44" x 1.2" x 0.47"	Velocity (-80 fps)	0.24	

**APPENDIX C:**  
**COMBINED TEST RESULTS TABLE**

Robert's New Type

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. TuFI-2

Date: 12/10/98

Time: 4:00

Conditions: Rainy 46°F

Staff: \_\_\_\_\_

Target Description:

Serial No. Robert's  
Obliquity (deg.): 60°

Projectile Description:

Projectile Dimensions: 1" x 1" x 1"  
Projectile Weight (g): \_\_\_\_\_  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): .6

Gun Pressure (psi): P1: 600, P2: 180, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.	_____	1575

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

Coating Delamination 2.5" x 1.5"

Comments:

- Special New Tile Design
- Intended Velocity 1600
- Projectile Slightly Broken Up - OK
- Good Test

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. TUF I - 1

Date: 12/11/98

Time: 10:50

Conditions: 43° F

Staff: \_\_\_\_\_

Target Description:

Serial No. TUF I - 1

Obliquity (deg.): 50°



Projectile Description:

Projectile Dimensions: "1" x "1" x "3"

Projectile Weight (g): 1.22

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 200, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

guess 1432 fps

Tile Damage Assessment:

Crater ~~(Y/N)~~ Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: 1/8"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking ~~(Y/N)~~ - Describe:

Comments:  
- No Impact / No Velocity  
- Probably Broken Projectile like test 60

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 104

Date: 1/5/98  
Time: 3:45  
Conditions: Sunny 55°  
Staff: DHG

Target Description:

Serial No. FIT tile  
Obliquity (deg.): 30°



Projectile Description:

Projectile Dimensions: 3/8" X 3.0"  
Projectile Weight (g): .23  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.		<u>1250</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

$\approx 1.01$ " dia X 0.9" deep

Comments:

- same FIT tile as Test No. New 99B - new spot +
- Good Test - Velocity (+50 fps)
- Projectile slightly broken up

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 103

Date: 1/5/94

Time: 5:01

Conditions: Sunny 55°

Staff: DLG

Target Description:

Serial No. F17 tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 3/8" dia x 3.0" Length

Projectile Weight (g): .23g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 60, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1071

Tile Damage Assessment:

Crater (Y/N): Length: 1.5" Width: 1.0" Depth: 0.5"

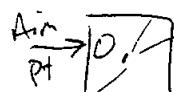
Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Pretest Cracks
- Good Test Velocity (+ 46 fps)
- Projectile Slightly Broken Up - Back 1/4



NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 101 B

Used for  
101 and 102  
✓

Date: 1/5/98

Time: 4:50

Conditions: Sunny 55°

Staff: DLG

Target Description:

Serial No. Eg tile  
Obliquity (deg.): 100°  
  
30°

Projectile Description:

Projectile Dimensions: 3/8" dia x 3.0" length  
Projectile Weight (g): .23 g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 85, P3: 600

Velocity Measurement:

<u>Measurement</u>	<u>Time (us)</u>	<u>Velocity (fps)</u>
1	_____	_____
2	_____	_____
Ave.		<u>1317</u>

Tile Damage Assessment:

Crater (Y/N): Length: 1.85" Width: 1.08" Depth: 0.5"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N - Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Good Test - Velocity (+101 fps)  
\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 101A

Date: 1/5/99  
Time: 4:40  
Conditions: Sunny 55°  
Staff: DLG

Target Description:

Serial No. Erg Tile  
Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 3/8" dia x 3.0"  
Projectile Weight (g): .23g  
Sabot Weight (g): \_\_\_\_\_  
Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 400, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	_____	_____
2	_____	_____
Ave.	_____	<u>1400</u>

Tile Damage Assessment:

Crater (Y/N): Length: 1.6" Width: 0.8" Depth: 0.58"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

New Erg Tile  
Good Test - Velocity (+144 fps)  
Too Fast  
\_\_\_\_\_  
\_\_\_\_\_

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. New 101

Date: 1/5/98

Time: 4:30

Conditions: Sunny 55°

Staff: DL/GT

Target Description:

Serial No. FIT Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 3/8" dia X 3.0" Length

Projectile Weight (g): .23g

Sabot Weight (g): \_\_\_\_\_

Total Weight (g): \_\_\_\_\_

Gun Pressure (psi): P1: 600, P2: 110, P3: 600

Velocity Measurement:

Measurement

Time (us)

Velocity (fps)

1

\_\_\_\_\_

\_\_\_\_\_

2

\_\_\_\_\_

Ave.

\_\_\_\_\_

1567

Tile Damage Assessment:

Crater (Y/N): Length: 2.09" Width: .87" Depth: 0.58"

Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

\_\_\_\_\_  
\_\_\_\_\_

Comments:

- Some FIT Tile as Test # New 98A- New Spot
- Projectile Broke into pieces
- Velocity (+ 361 fps) - Too Fast
- Big Gorge

NASA - JSC  
Orbiter Tile Impact Testing  
SwRI Project No. 06-7503-005

Test No. 97 (H100)

This will be  
used as  
Test # 100  
in the Matrix

Date: 12/9/98

Time: 9:15

Conditions: Cloudy

51° F

Staff: DLG, LB, DJG

Target Description:

Serial No. Eng Tile

Obliquity (deg.): 60°



Projectile Description:

Projectile Dimensions: 3/8" dia x 1.0" Length

Projectile Weight (g): .089

Sabot Weight (g): —

Total Weight (g): .08

Gun Pressure (psi): P1: 600, P2: 50, P3: 600

Velocity Measurement:

Measurement	Time (us)	Velocity (fps)
1	—	—
2	—	—
Ave.	—	<u>929</u>

Tile Damage Assessment:

Crater (Y/N): Length: \_\_\_\_\_ Width: \_\_\_\_\_ Depth: \_\_\_\_\_

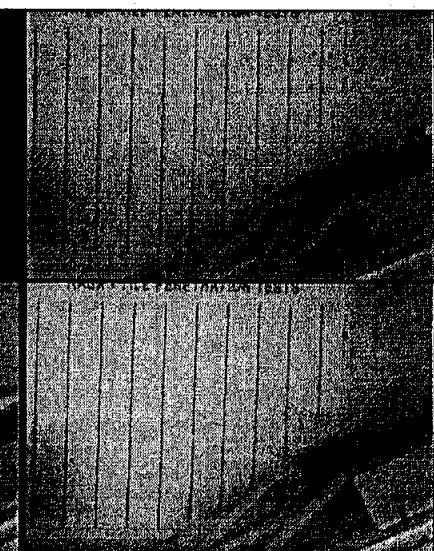
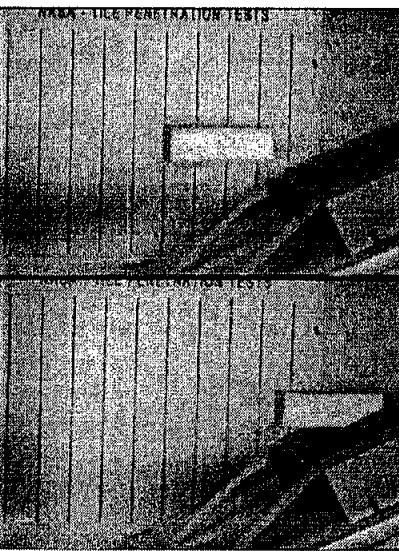
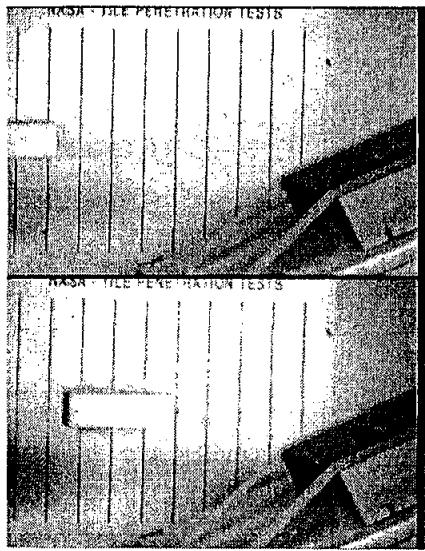
Volume: \_\_\_\_\_ (Weight of Sand \_\_\_\_\_ x Sand Density \_\_\_\_\_)

Tile Cracking (Y/N – Describe):

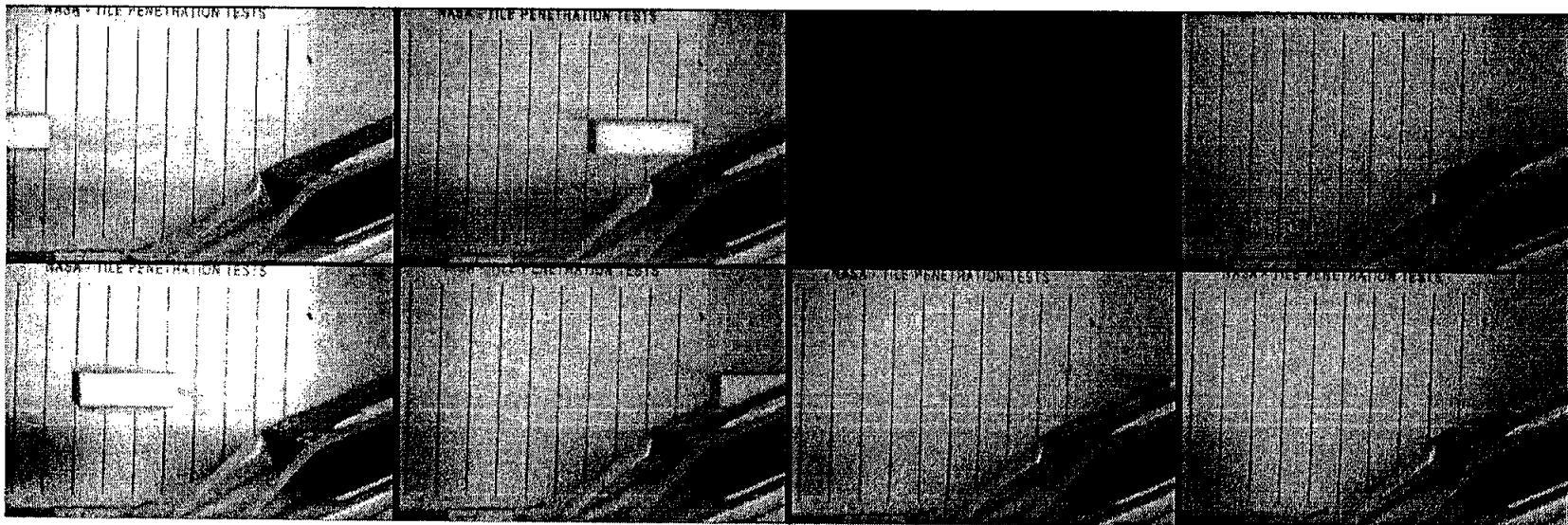
\_\_\_\_\_

Comments:

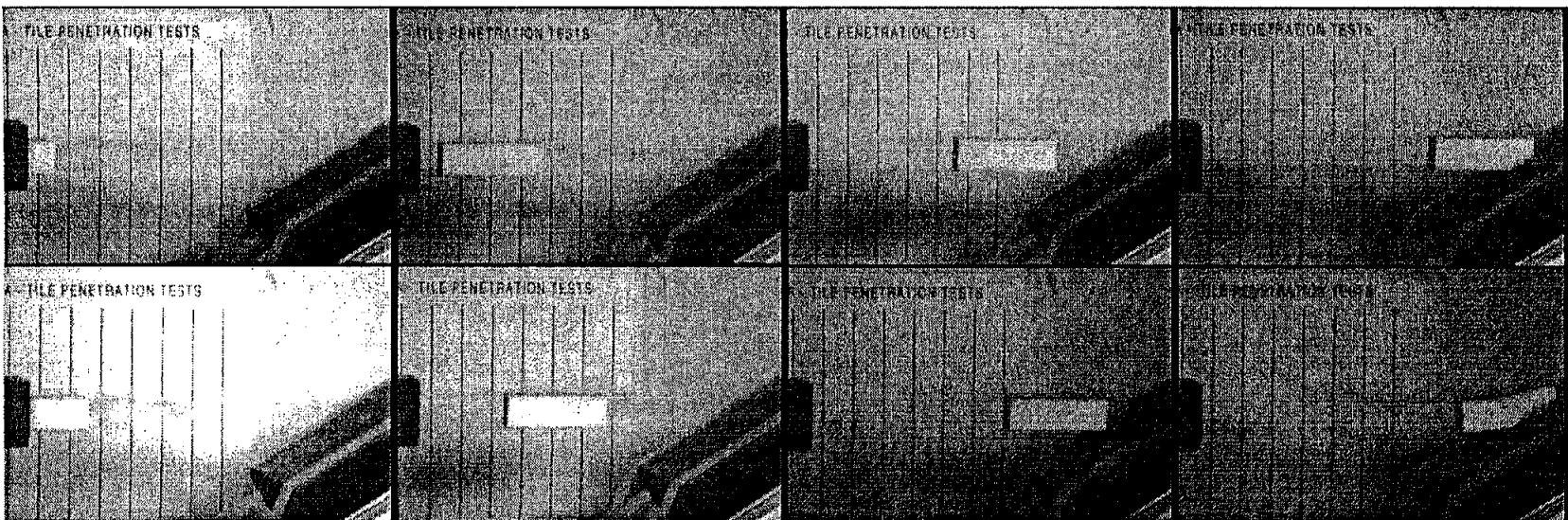
- 10" Standoff from Barrel to Impact site
- New Eng. Tile - NO cracking
- No Damage
- Intended Velocity 1009 (- 80 fps)



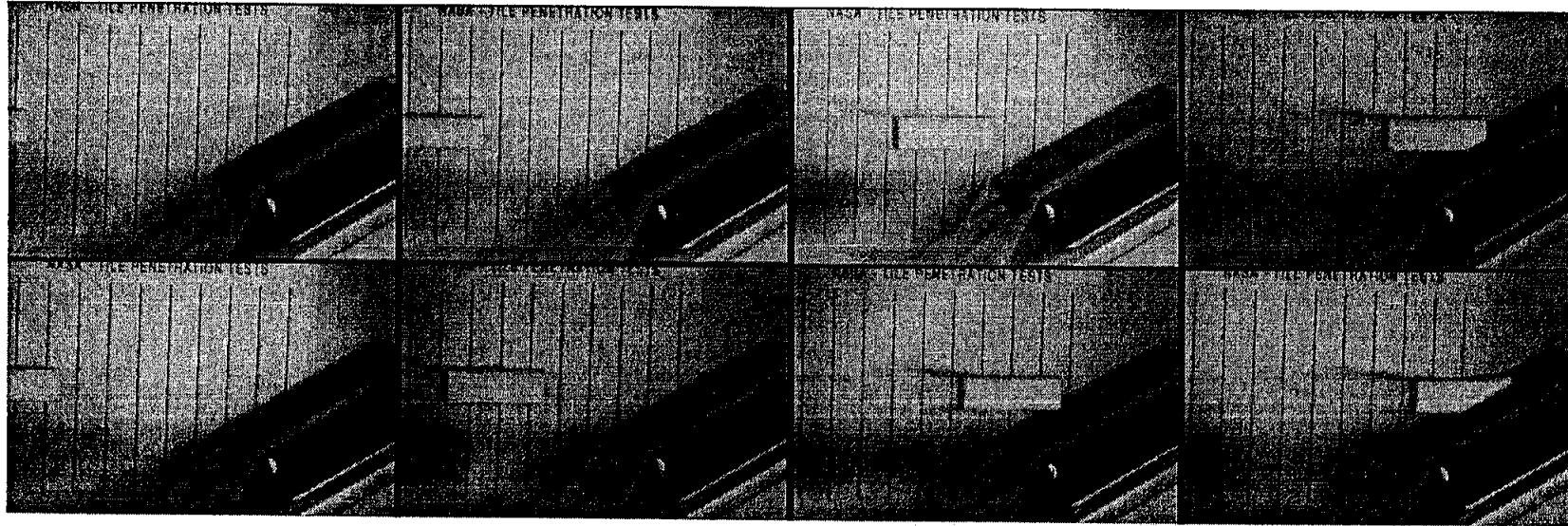
**Test No. 51B**



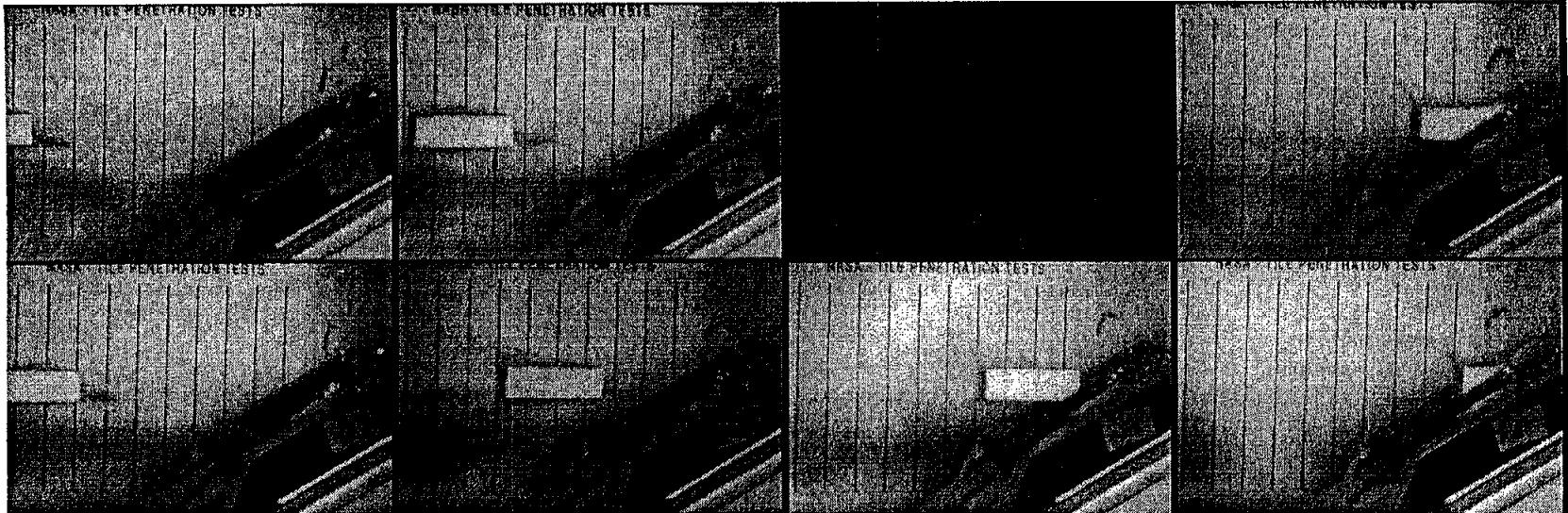
**Test No. 52B**



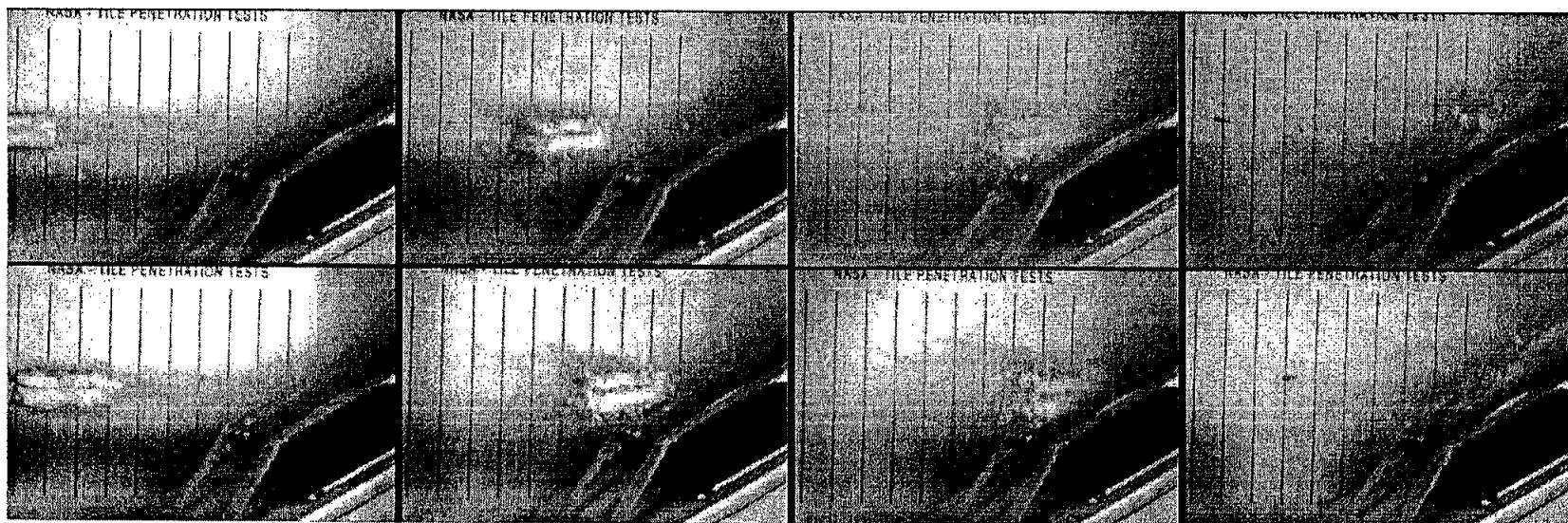
**Test No. 53**



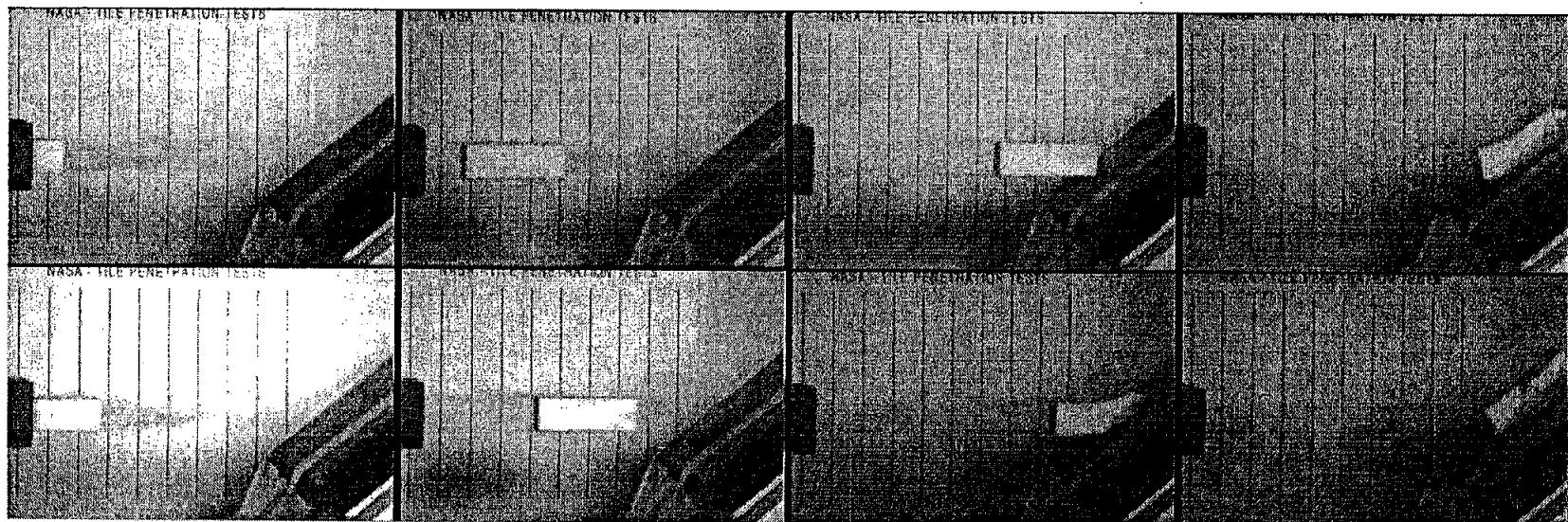
**Test No. 54**



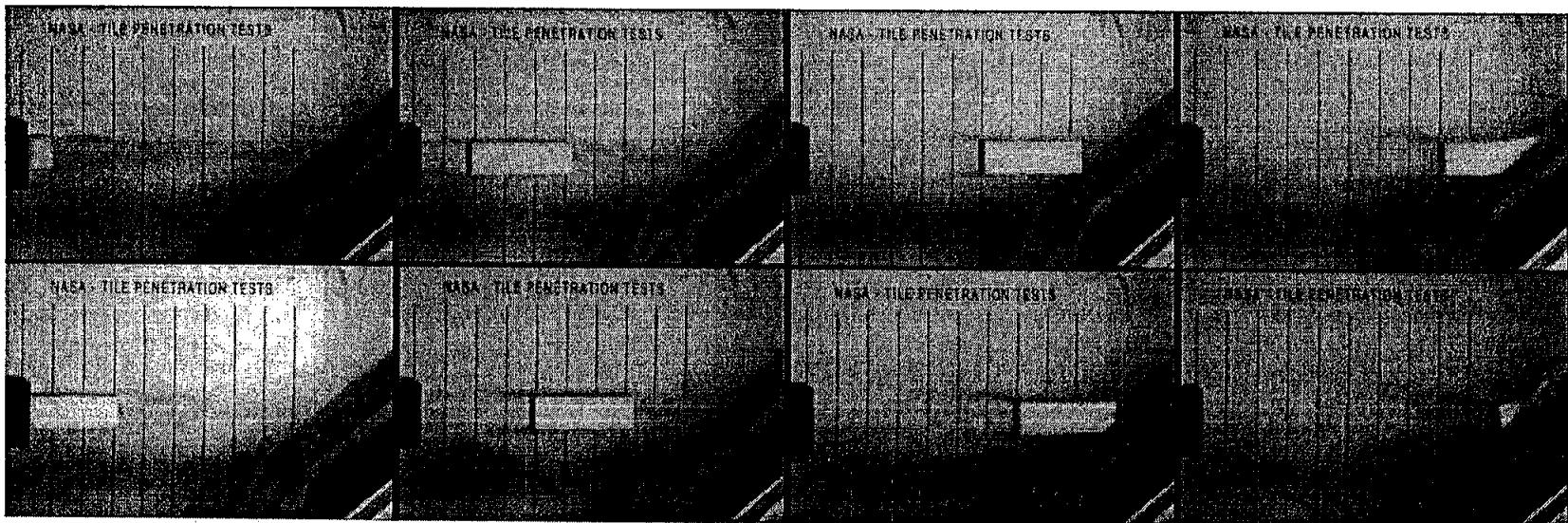
**Test No. 55**



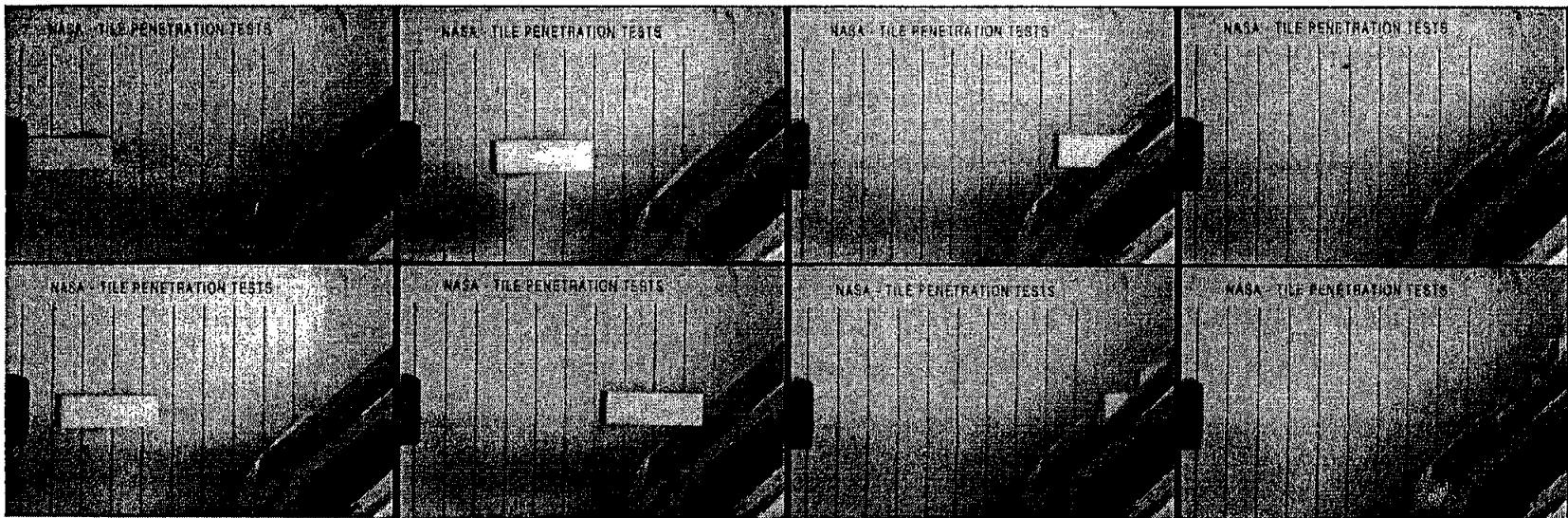
**Test No. 56**



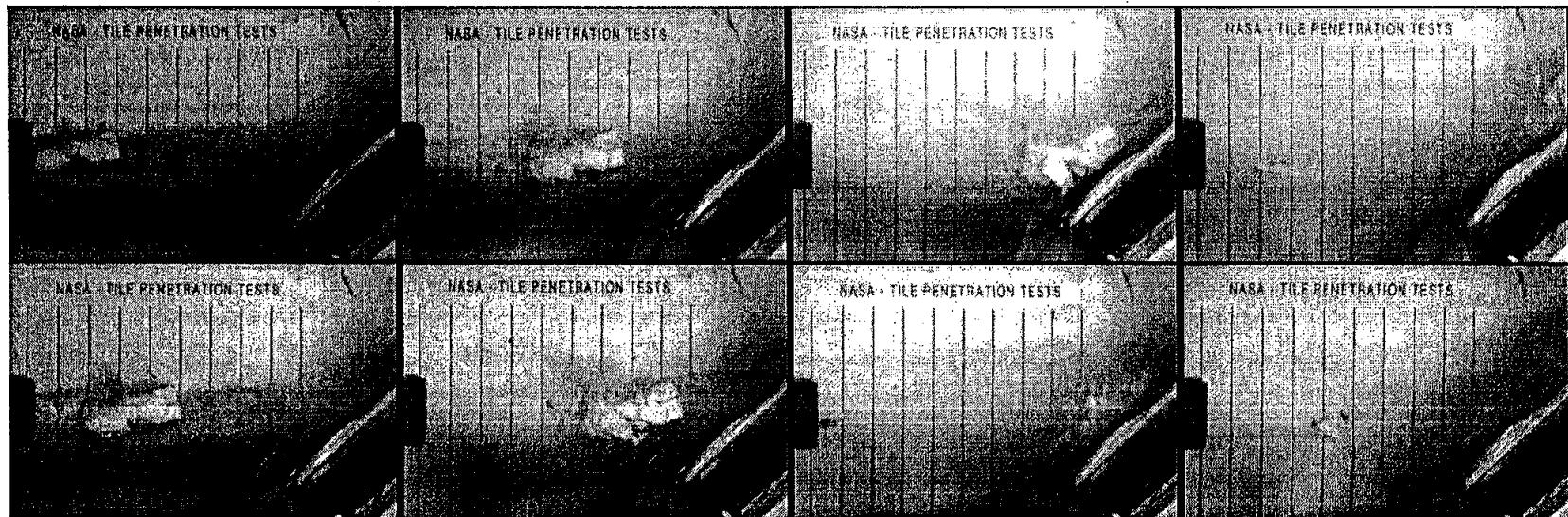
**Test No. 57A**



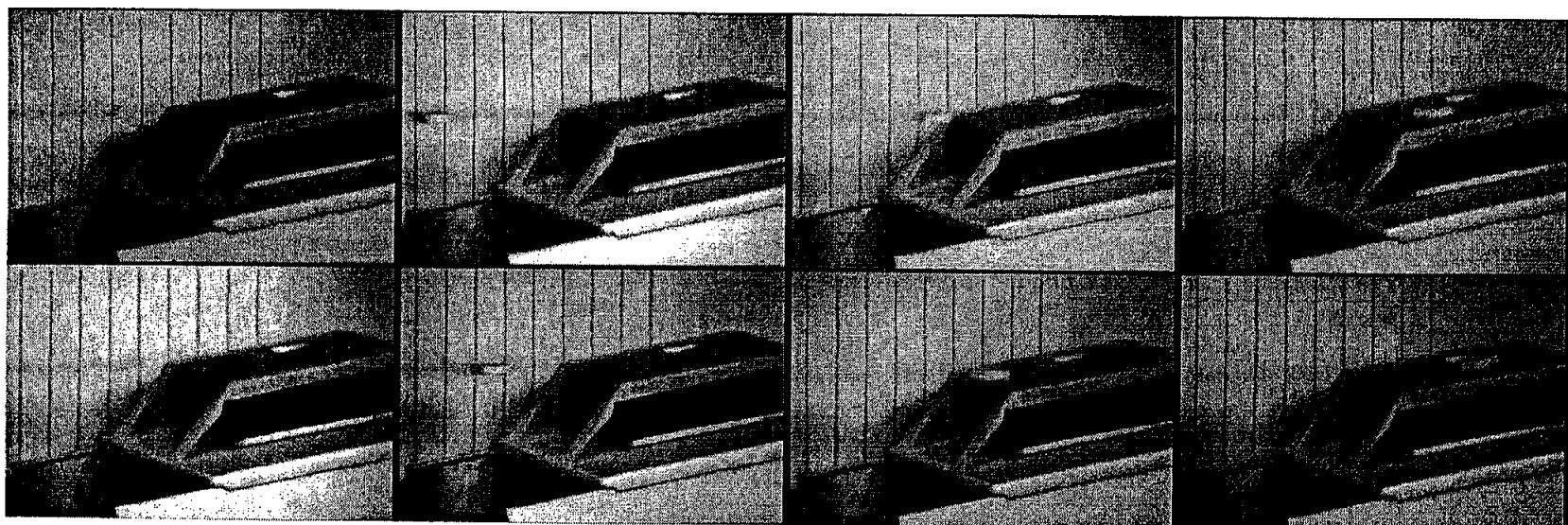
**Test No. 58**



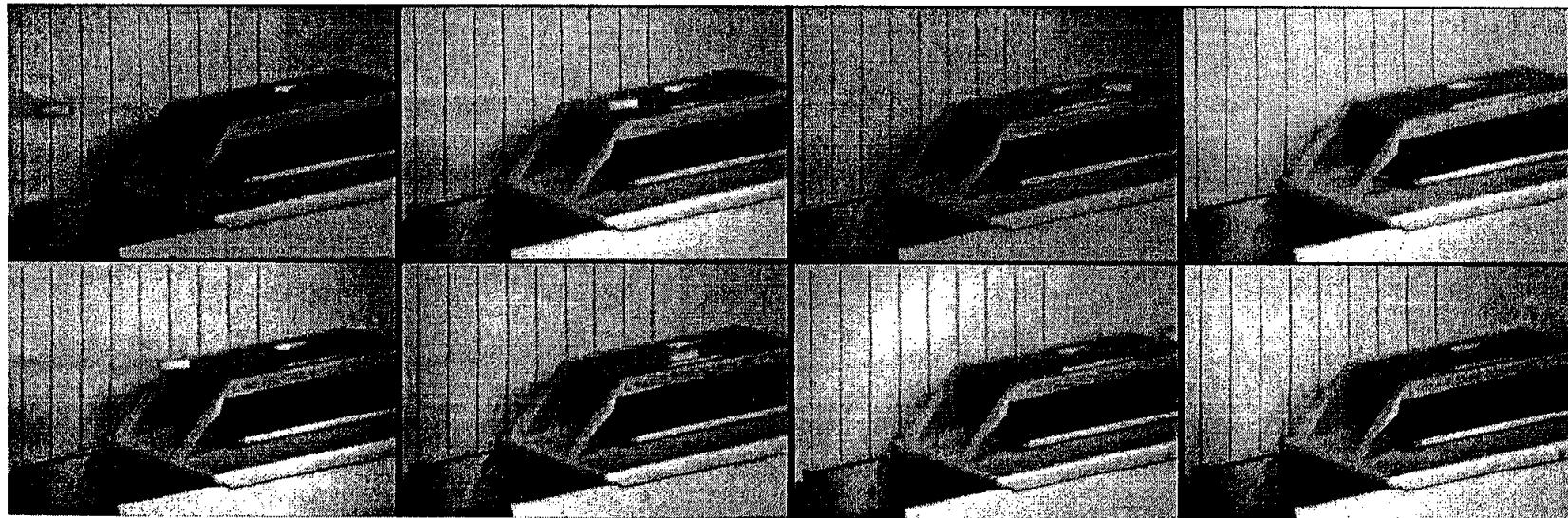
**Test No. 59A**



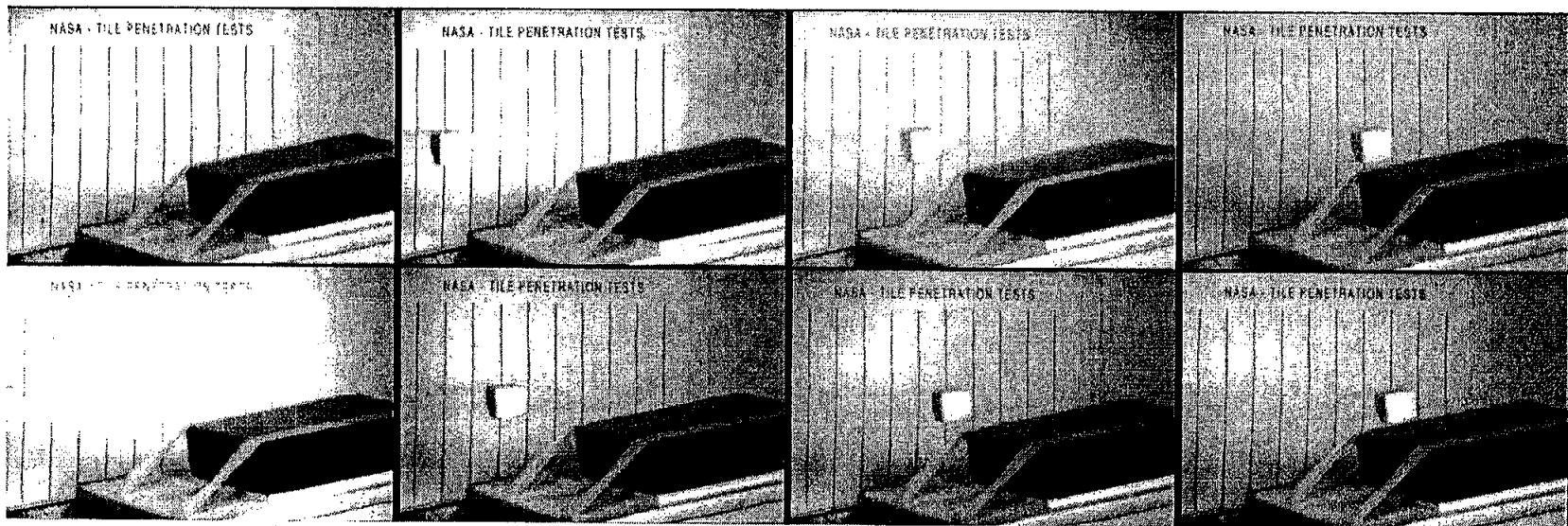
**Test No. 60**



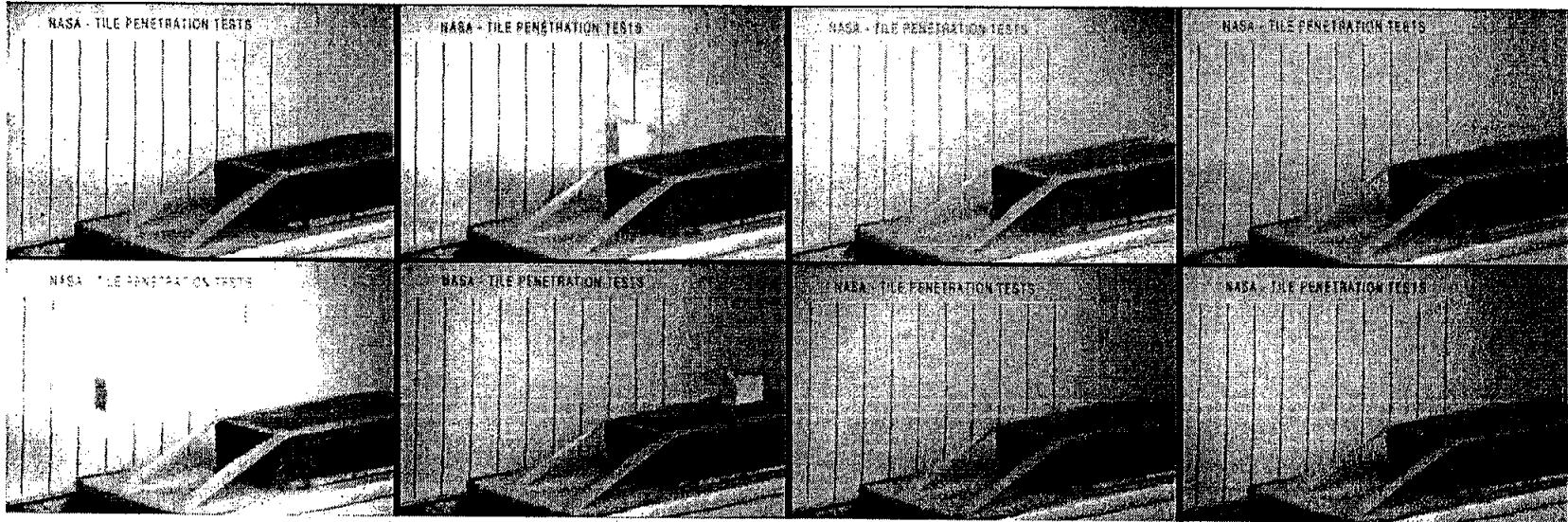
**Test No. 81**



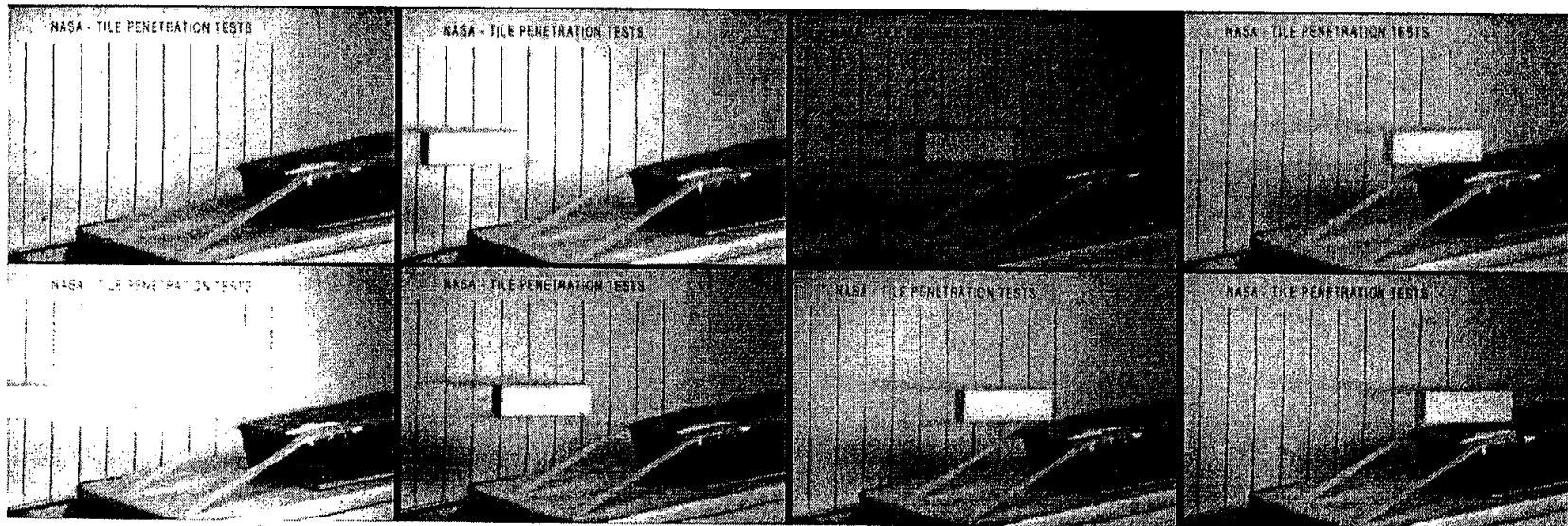
**Test No. 82**



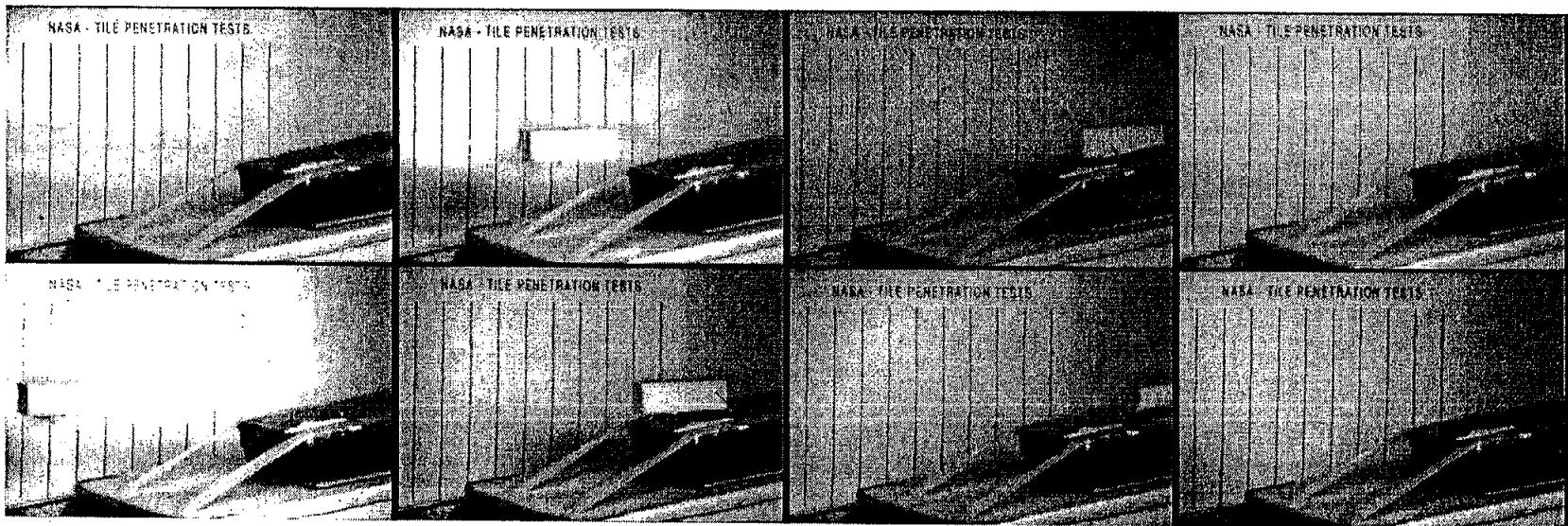
**Test No. 83**



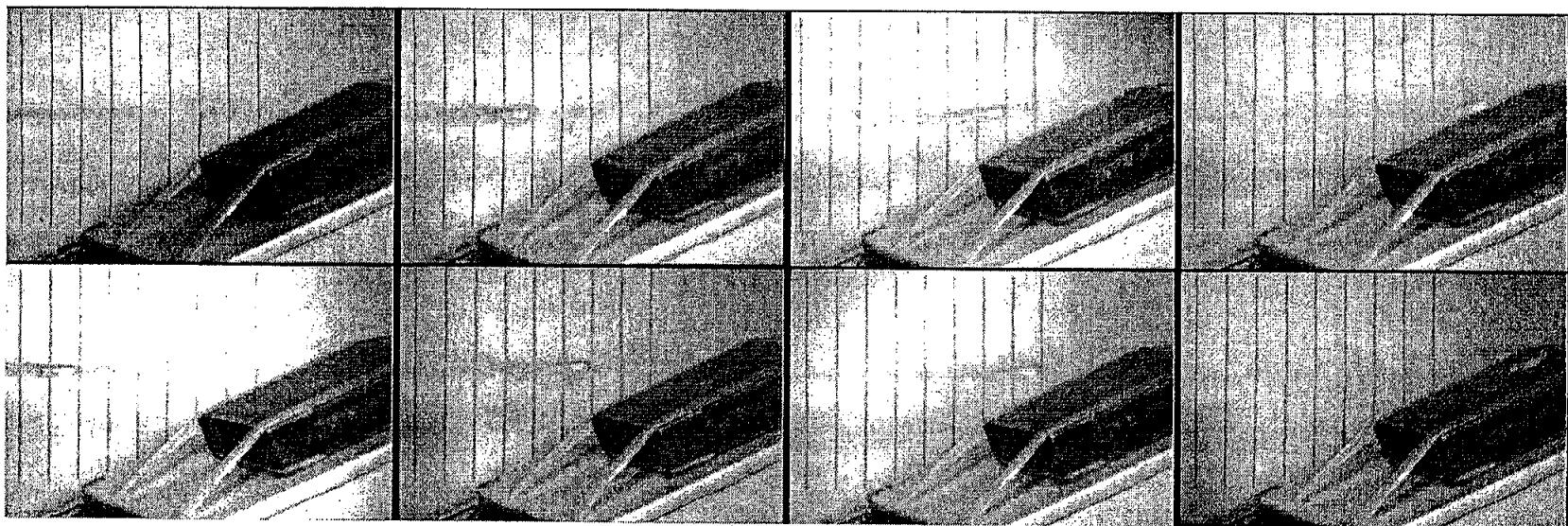
**Test No. 84B**



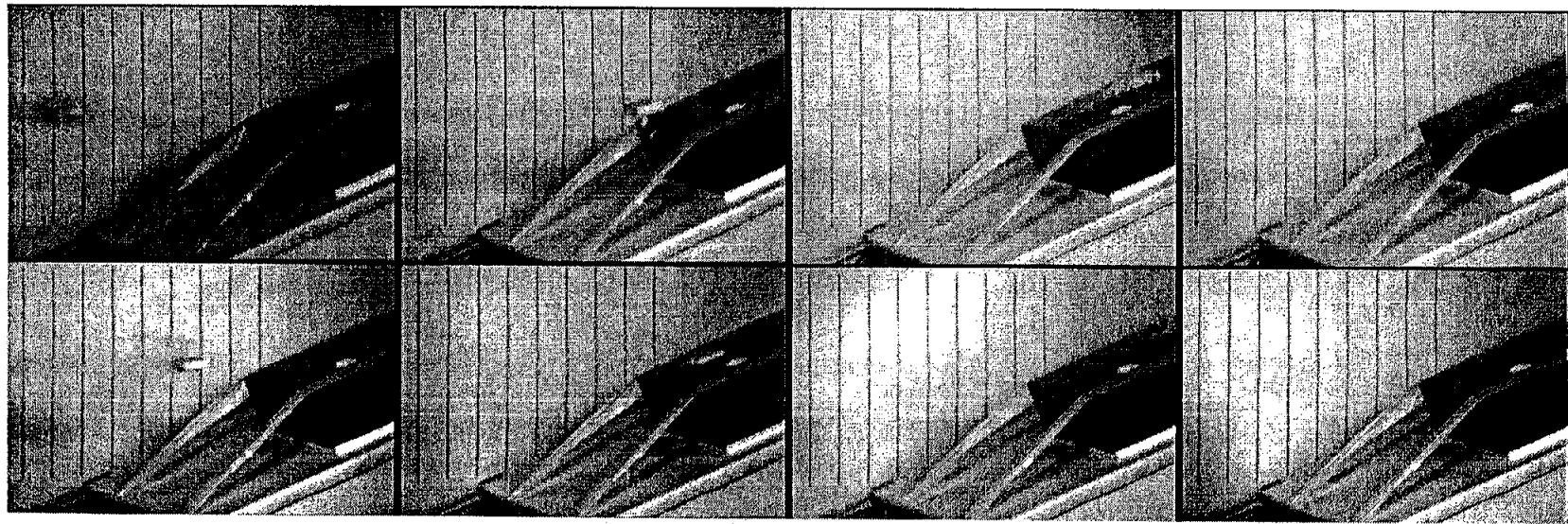
**Test No. 85**



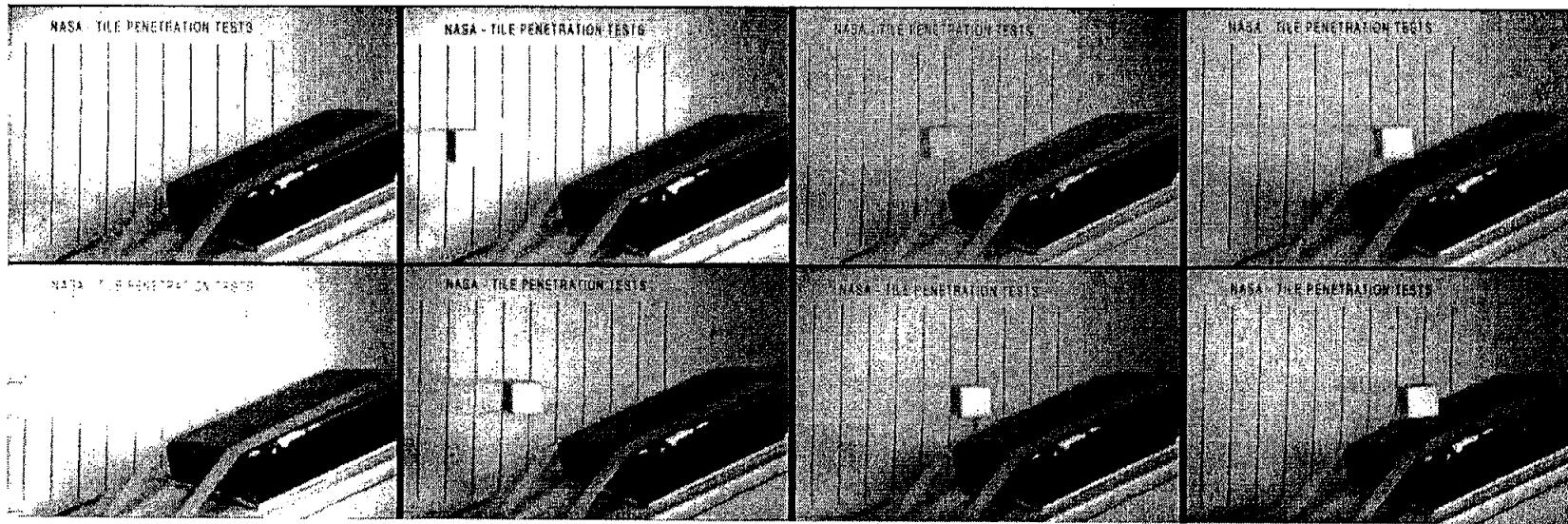
Test No. 86



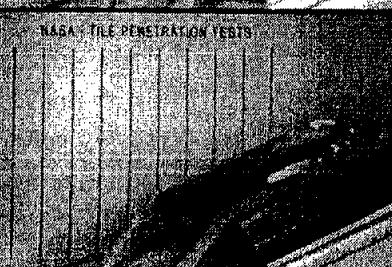
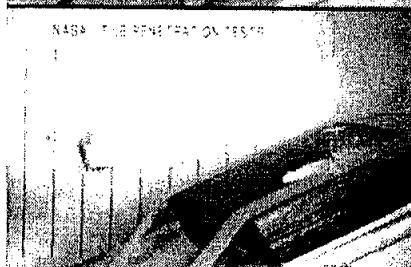
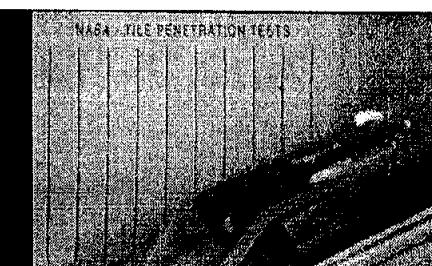
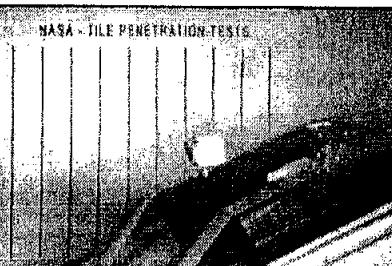
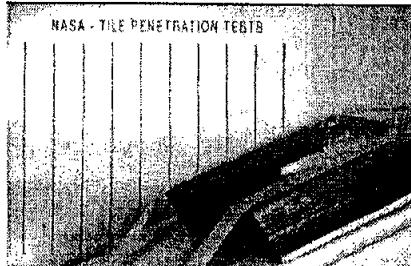
**Test No. 89**



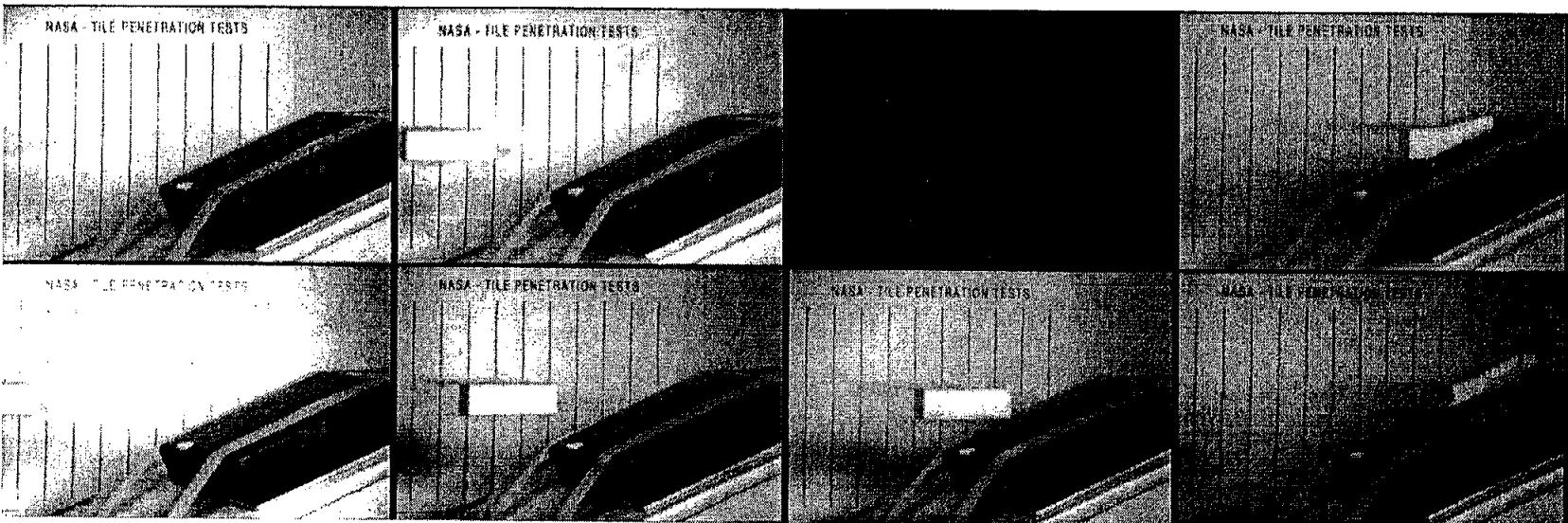
**Test No. 90B**



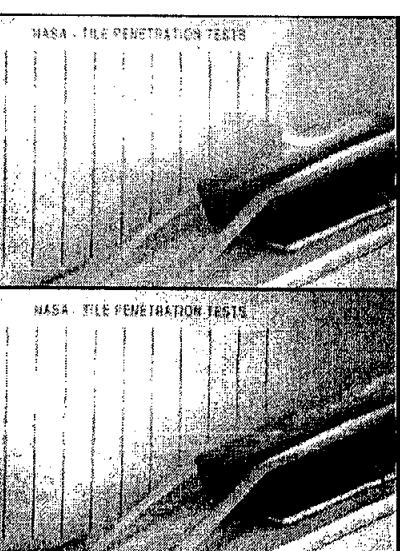
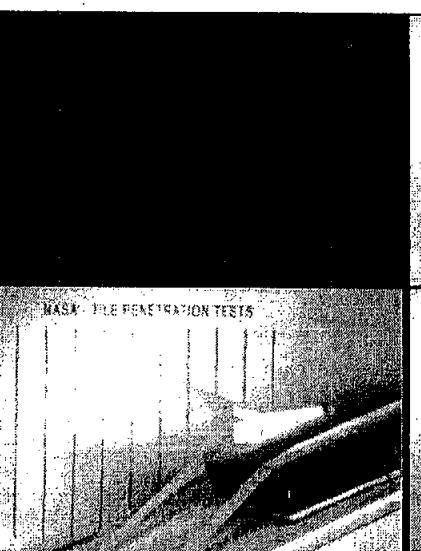
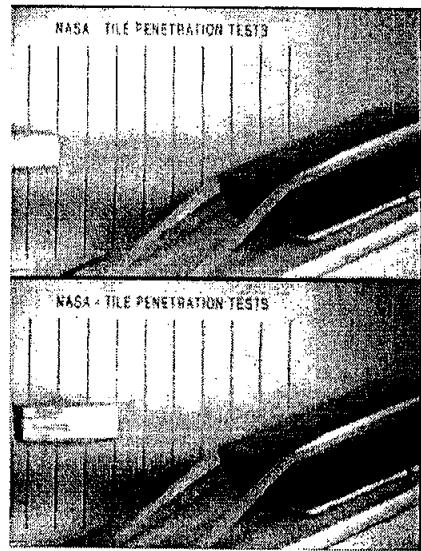
**Test No. 91**



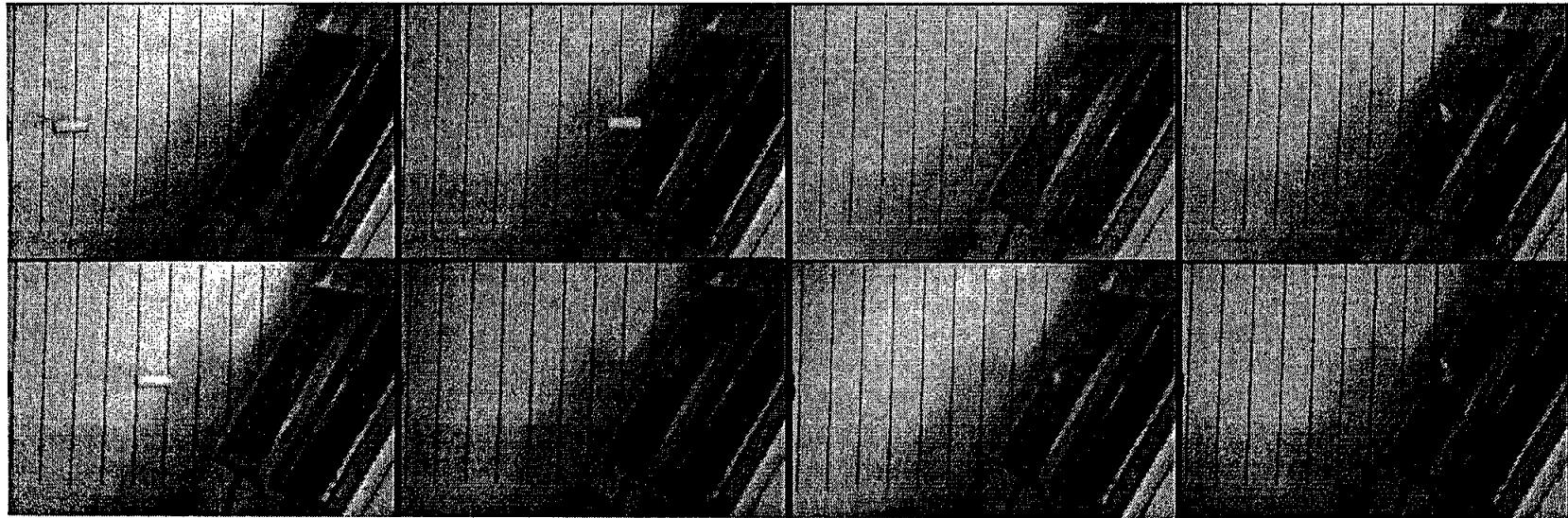
**Test No. 92**



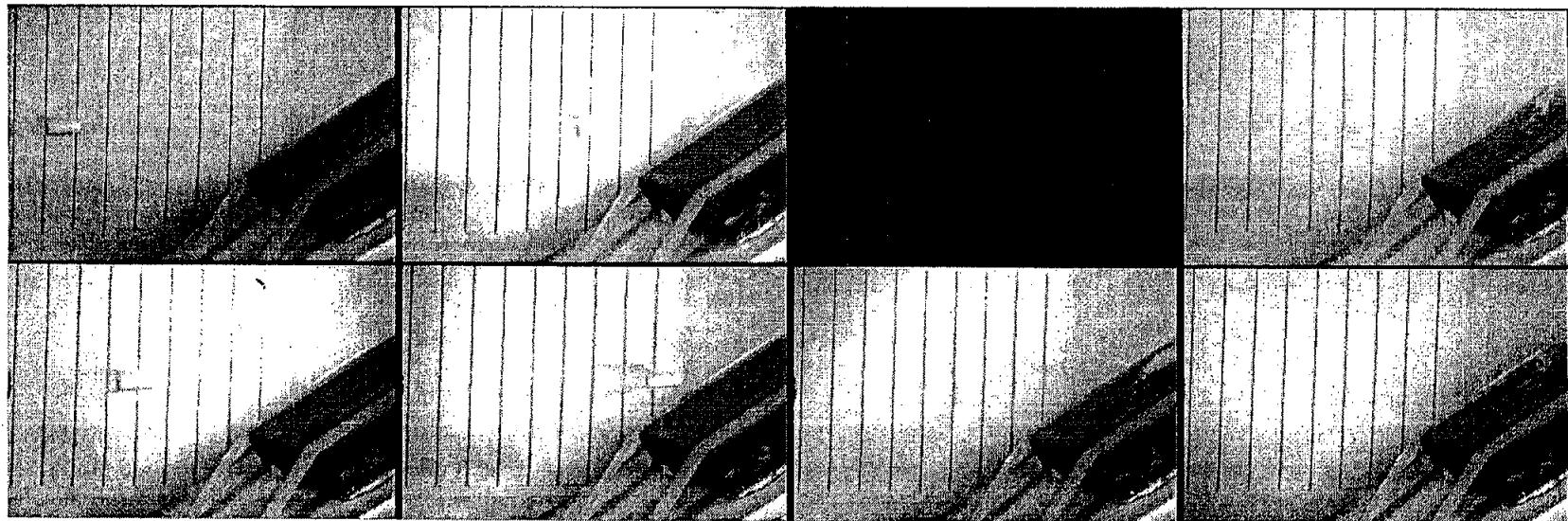
**Test No. 93**



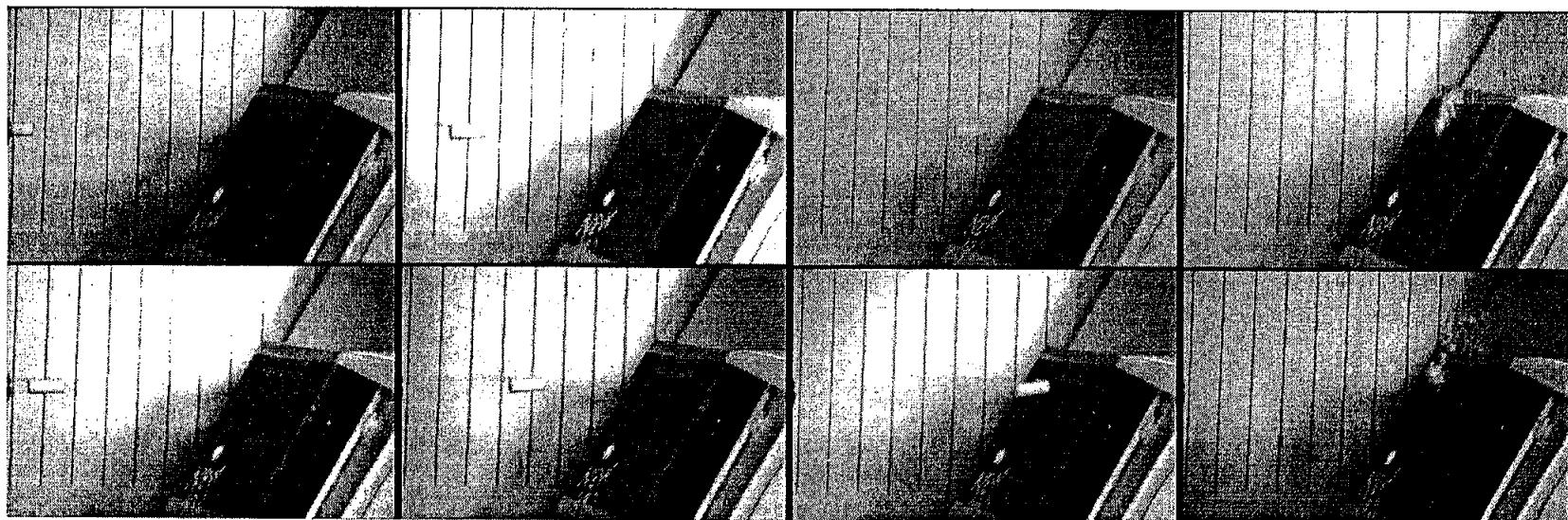
**Test No. 94A**



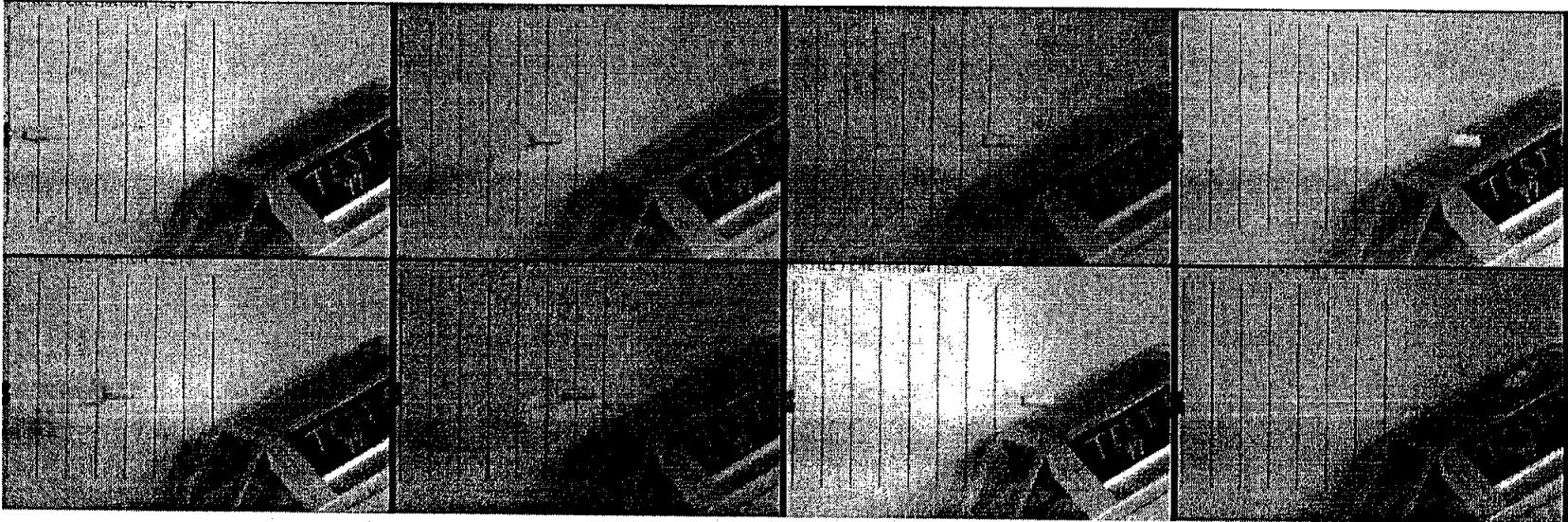
**Test No. 97**



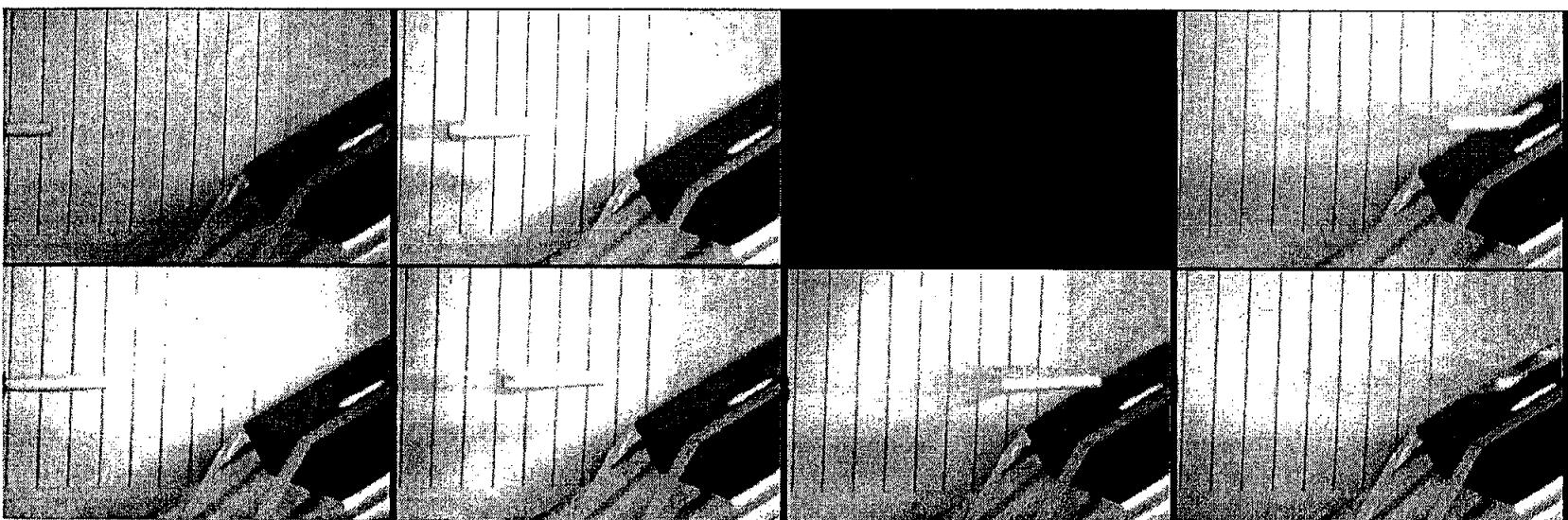
**Test No. 98A**



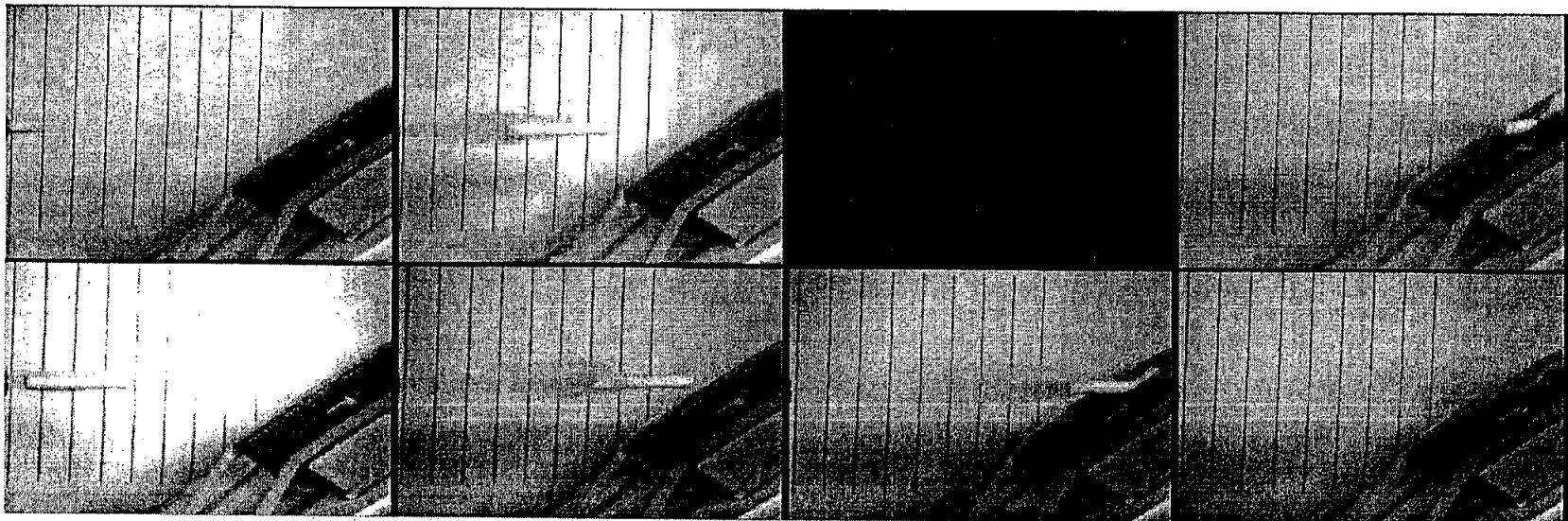
**Test No. 99B**



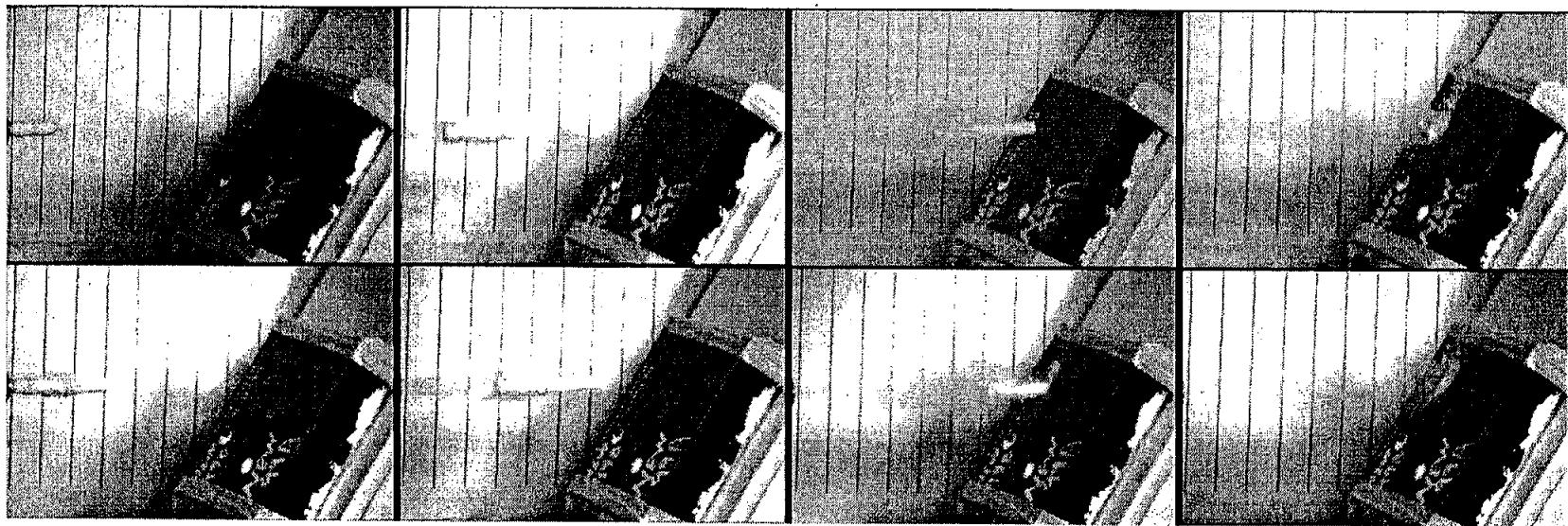
**Test No. 100**



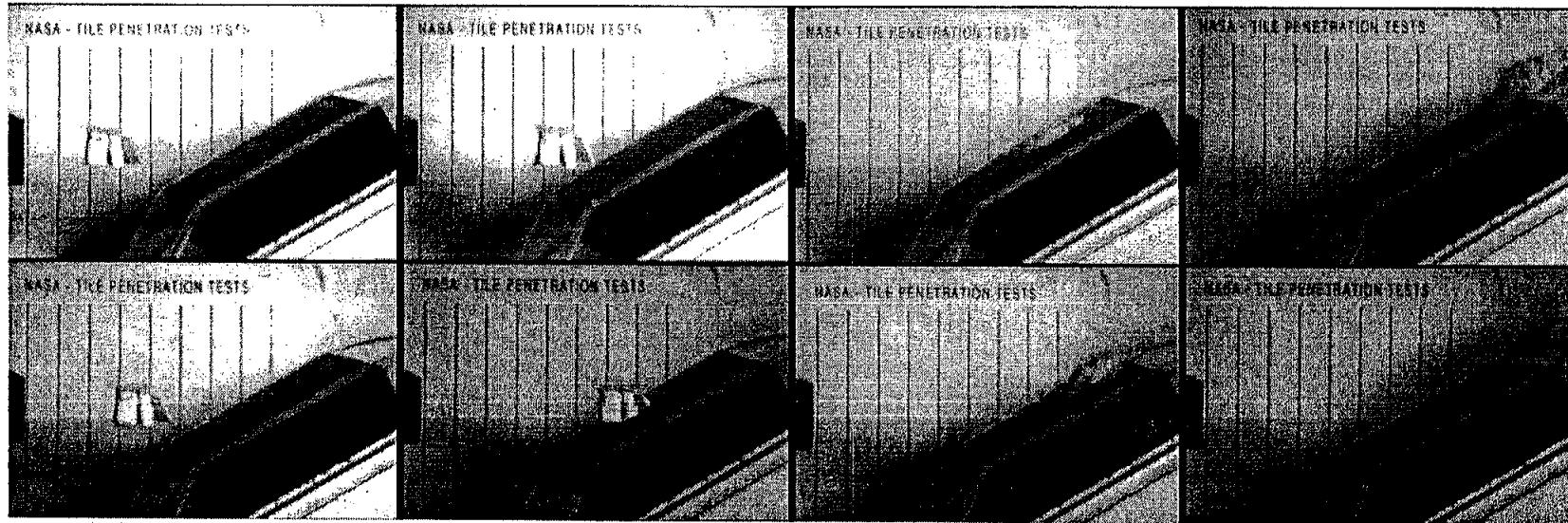
**Test No. 101B**



**Test No. 103**

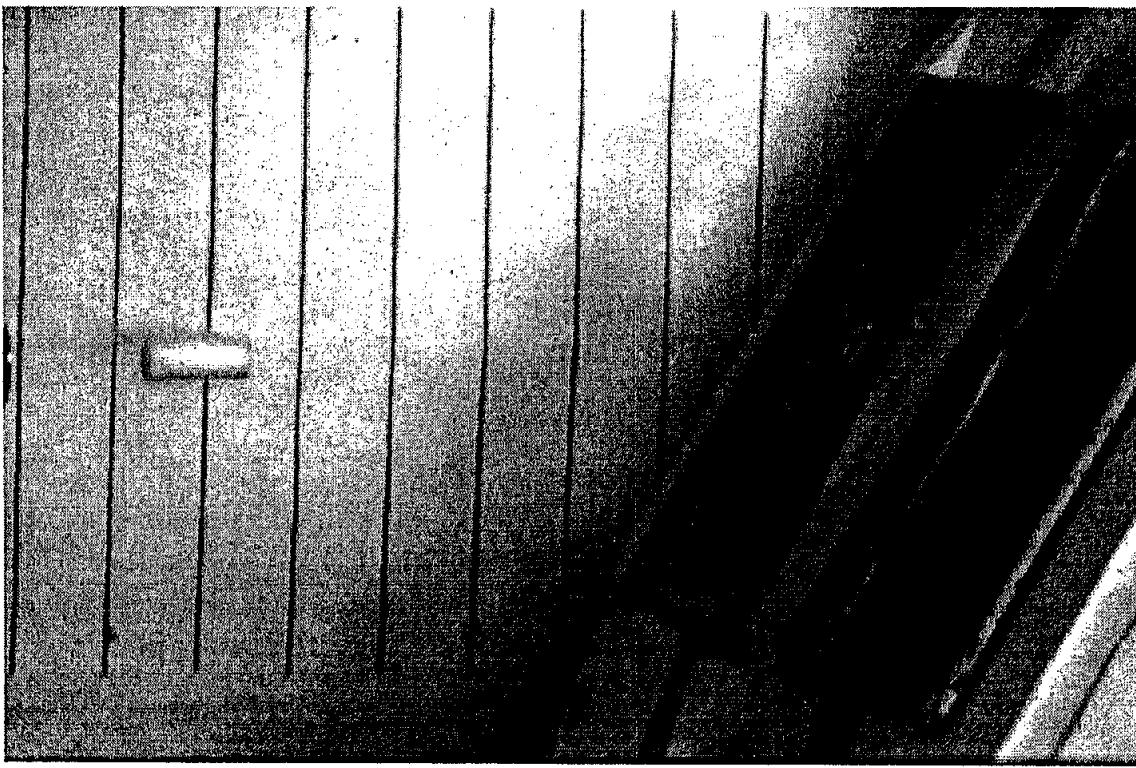


**Test No. 104**

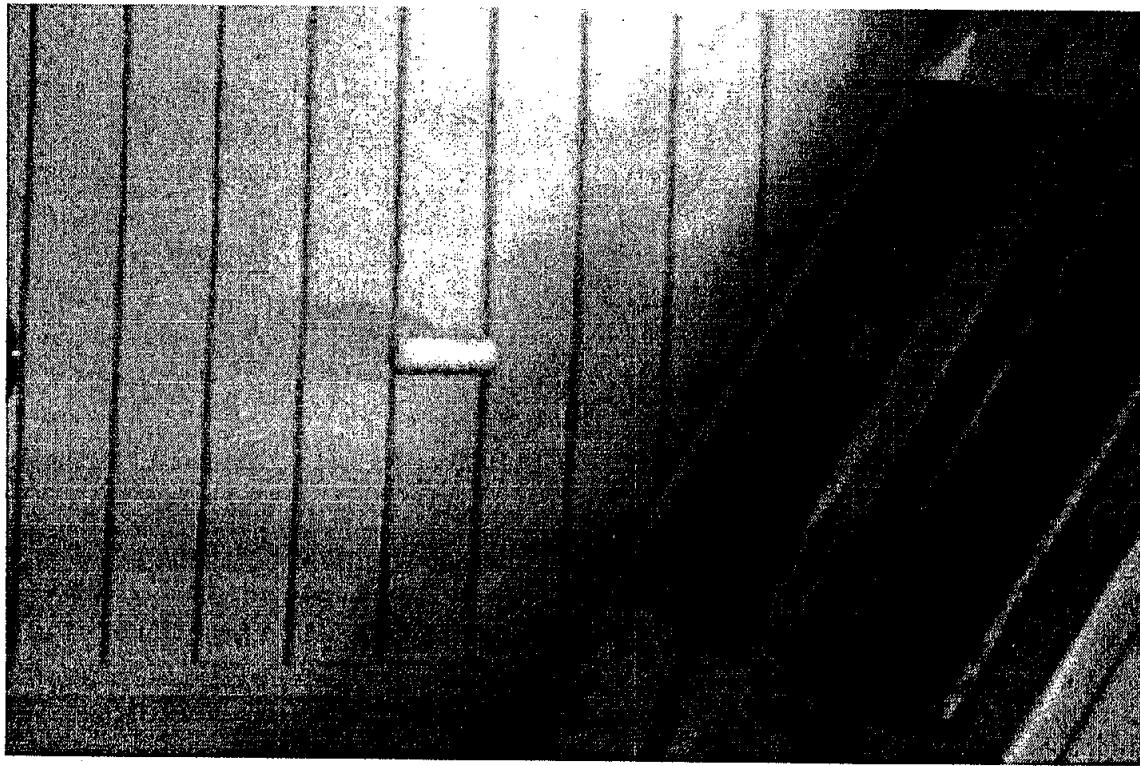


**Test No. Tufi-2**

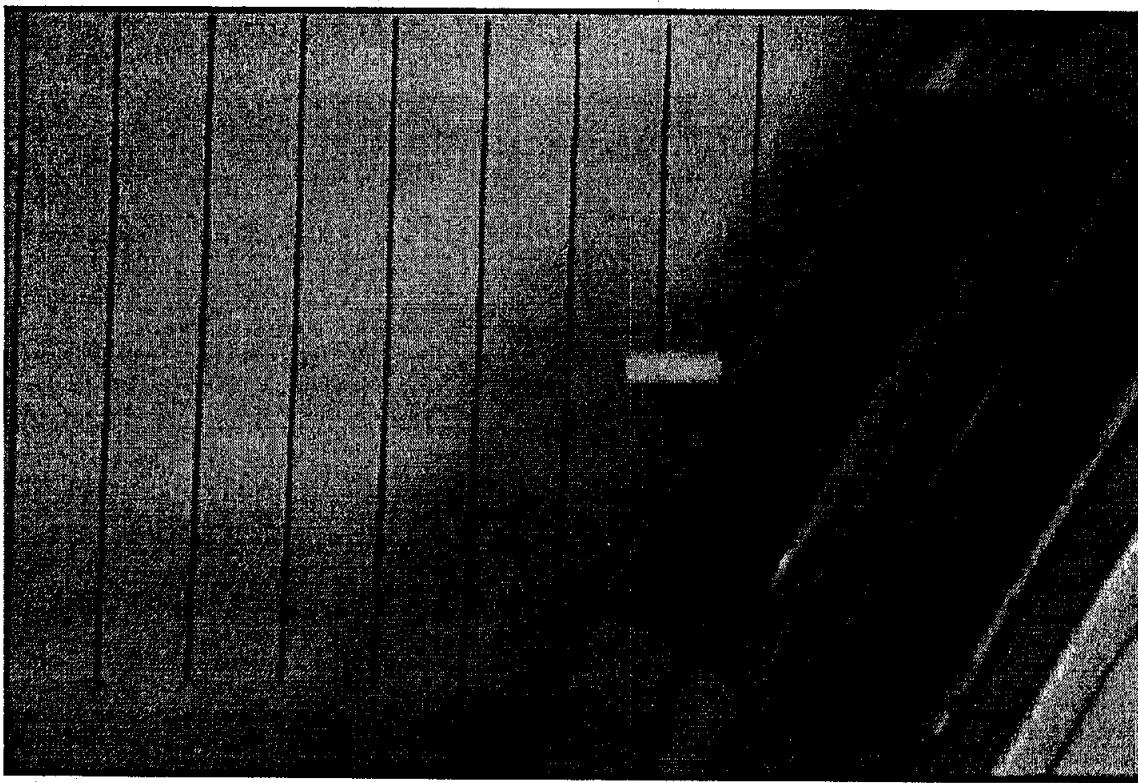
**APPENDIX E:**  
**EXAMPLE FULL-SIZE**  
**IMACON IMAGES**



**Test No. 97 - Imacon Frame No. 1**



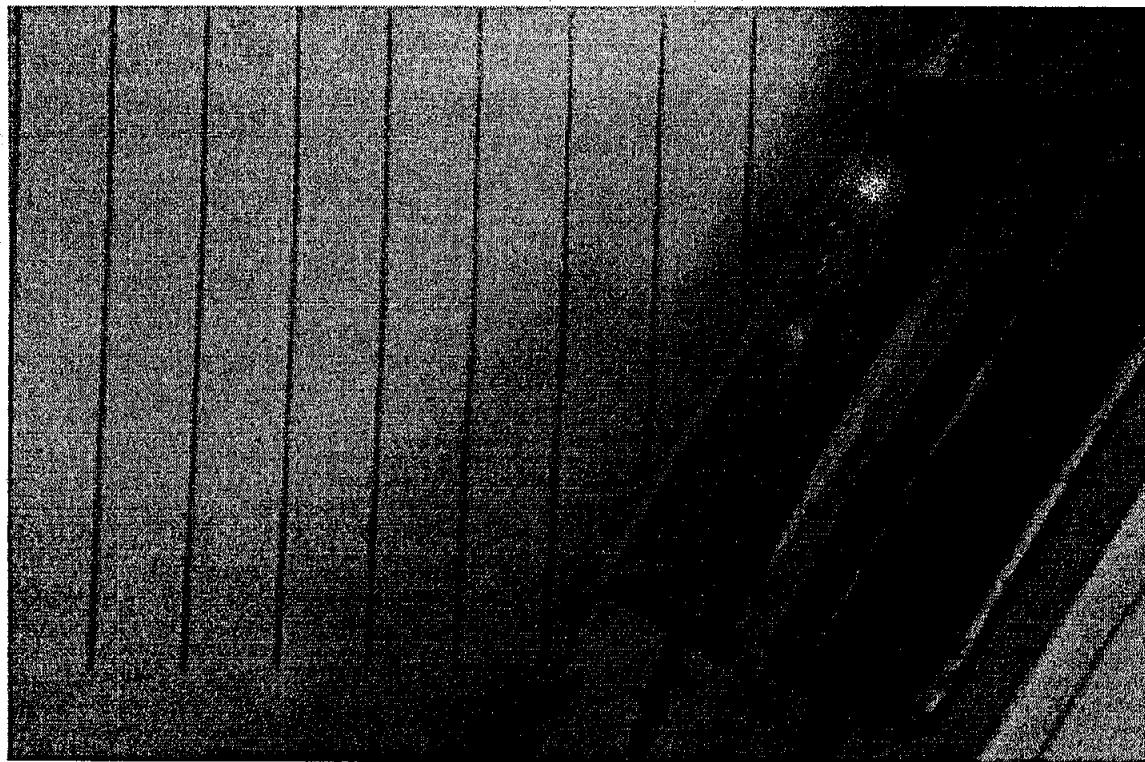
**Test No. 97 - Imacon Frame No. 2**



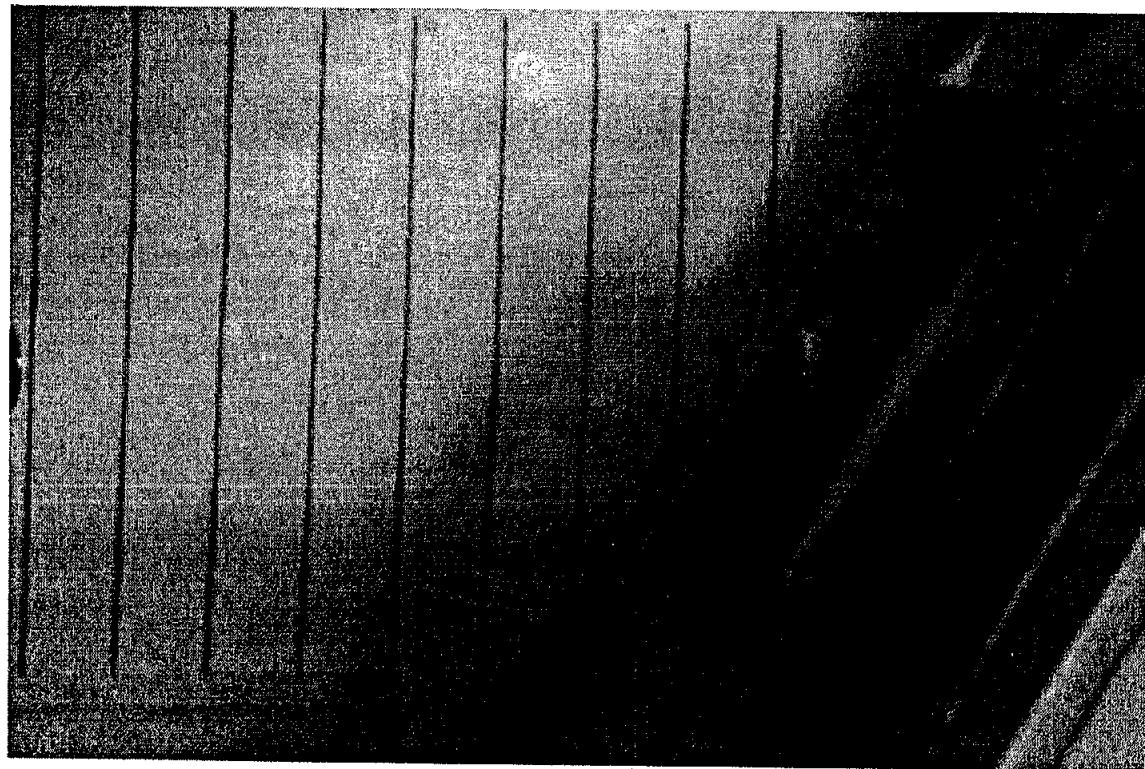
**Test No. 97 - Imacon Frame No. 3**



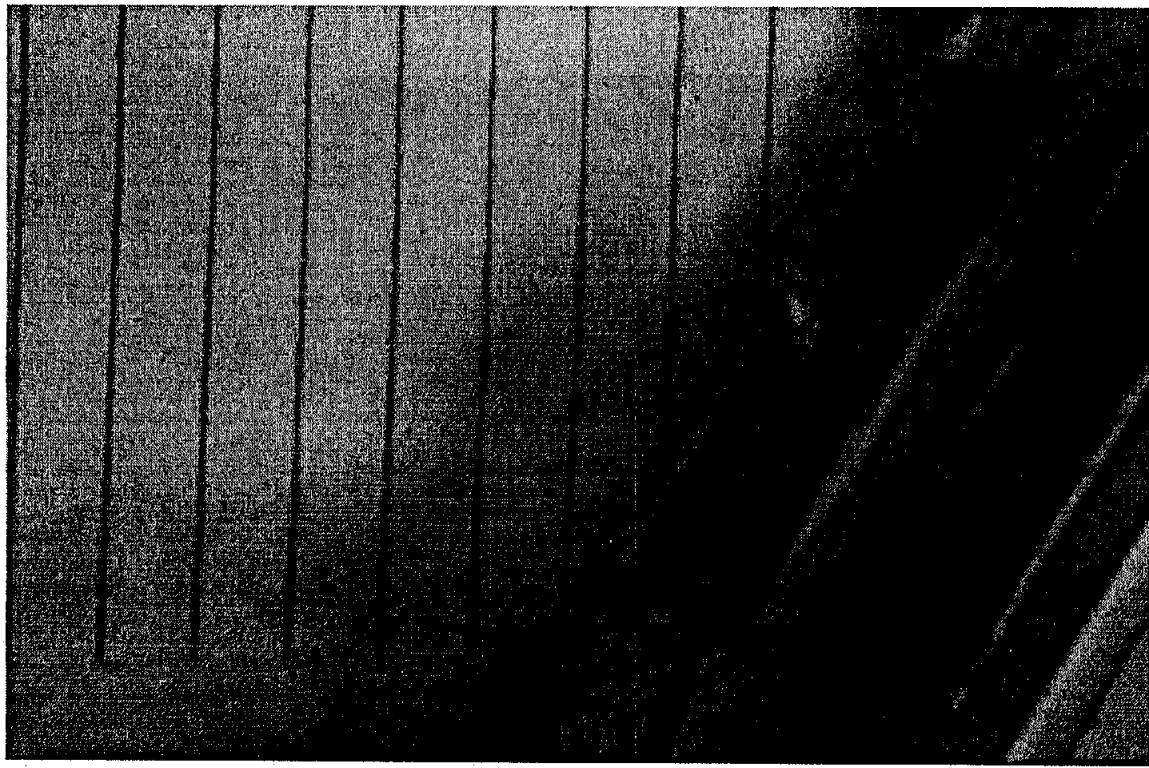
**Test No. 97 - Imacon Frame No. 4**



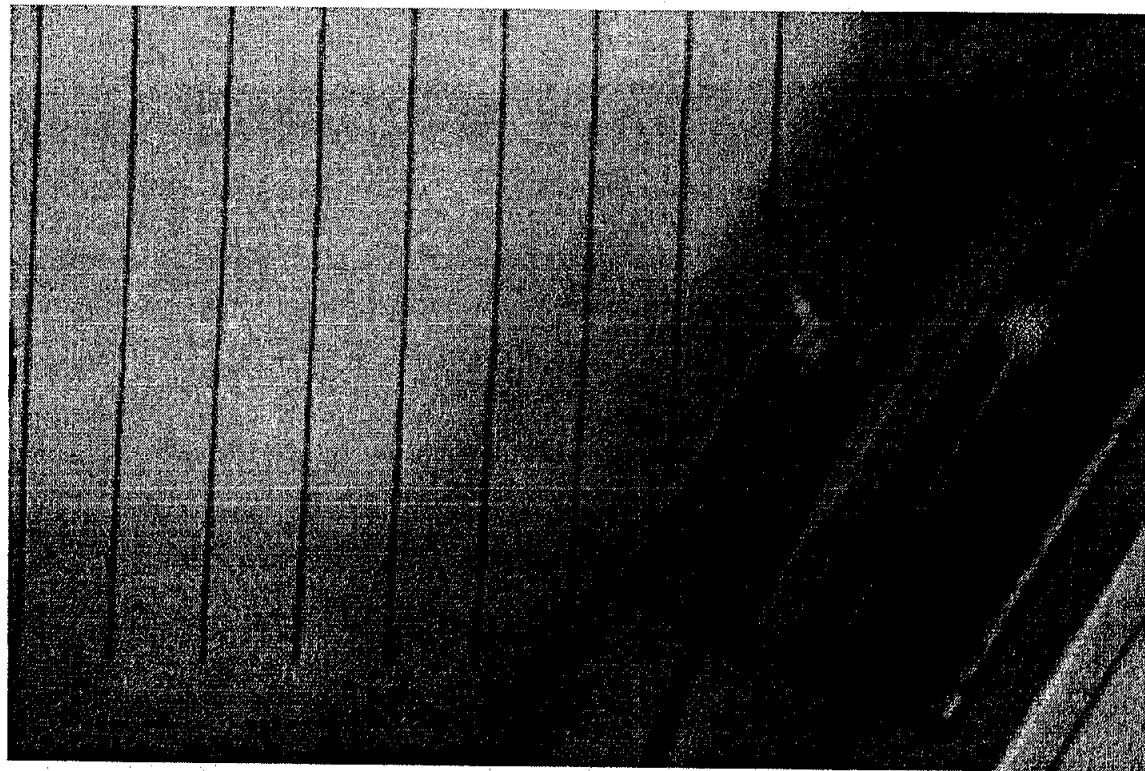
**Test No. 97 - Imacon Frame No. 5**



**Test No. 97 - Imacon Frame No. 6**



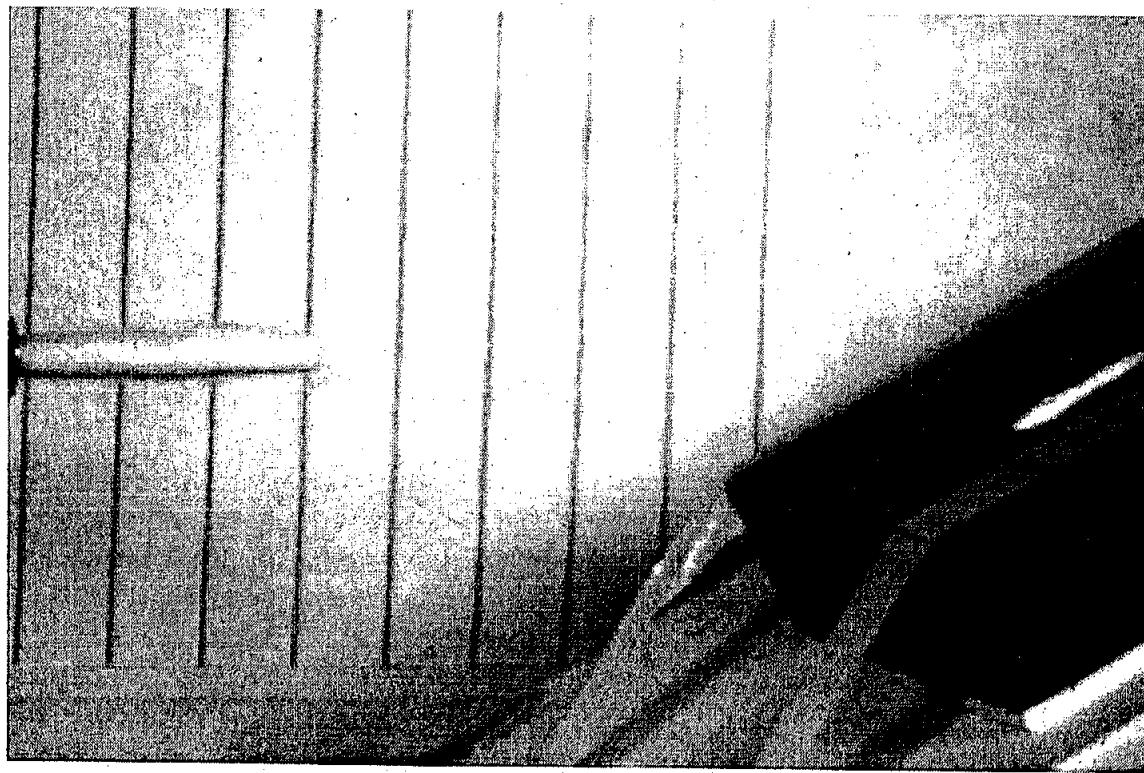
**Test No. 97 - Imacon Frame No. 7**



**Test No. 97 - Imacon Frame No. 8**



**Test No. New101(B) - Imacon Frame No. 1**



**Test No. New101(B) - Imacon Frame No. 2**



**Test No. New101(B) - Imacon Frame No. 3**



**Test No. New101(B) - Imacon Frame No. 4**



**Test No. New101(B) - Imacon Frame No. 6**

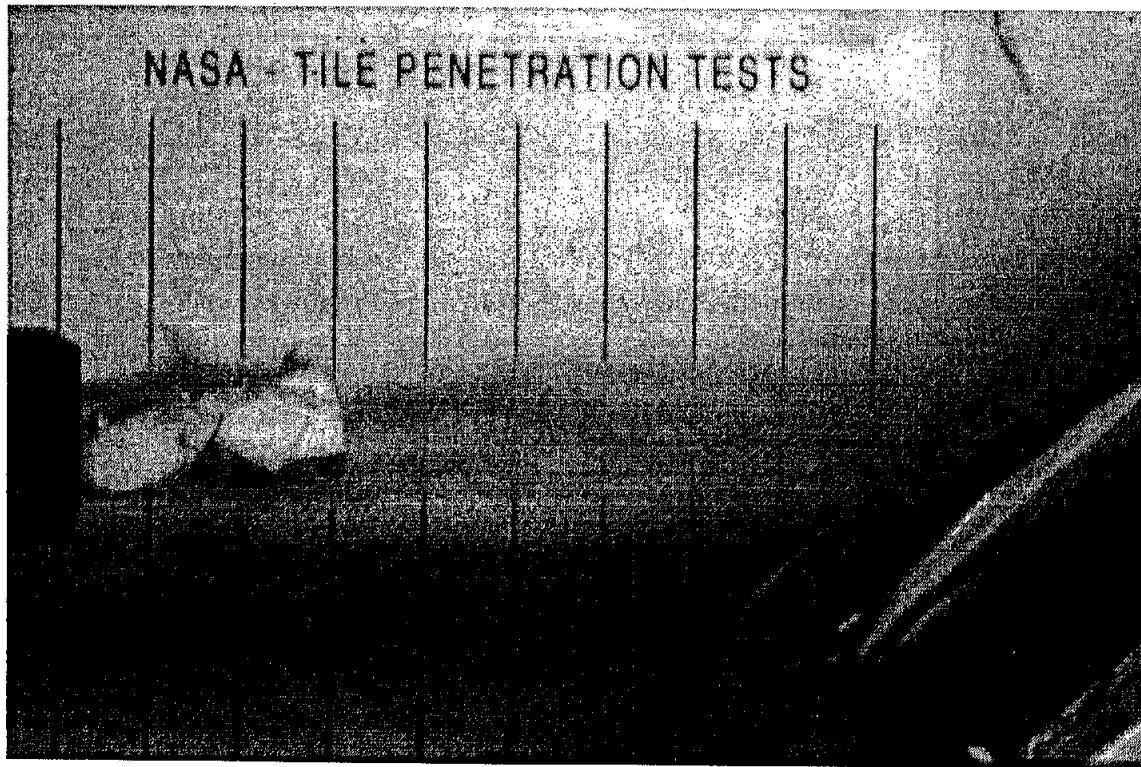


**Test No. New101(B) - Imacon Frame No. 7**



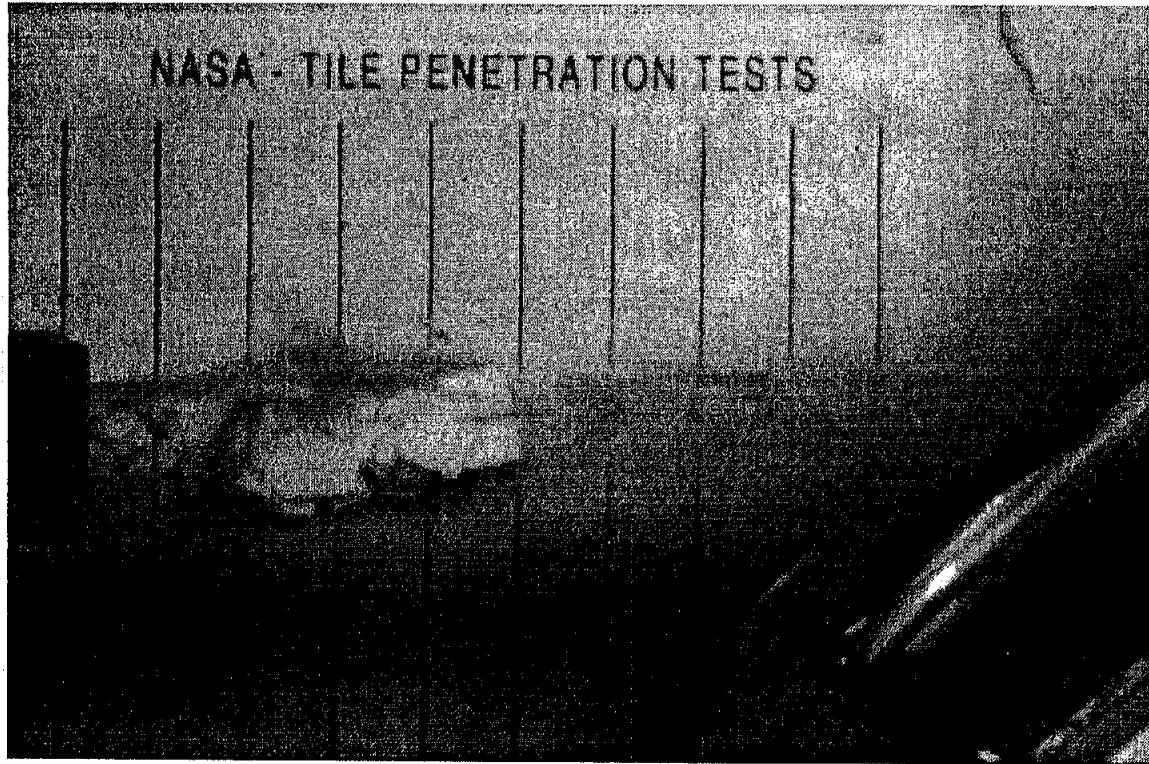
**Test No. New101(B) - Imacon Frame No. 8**

NASA - TILE PENETRATION TESTS



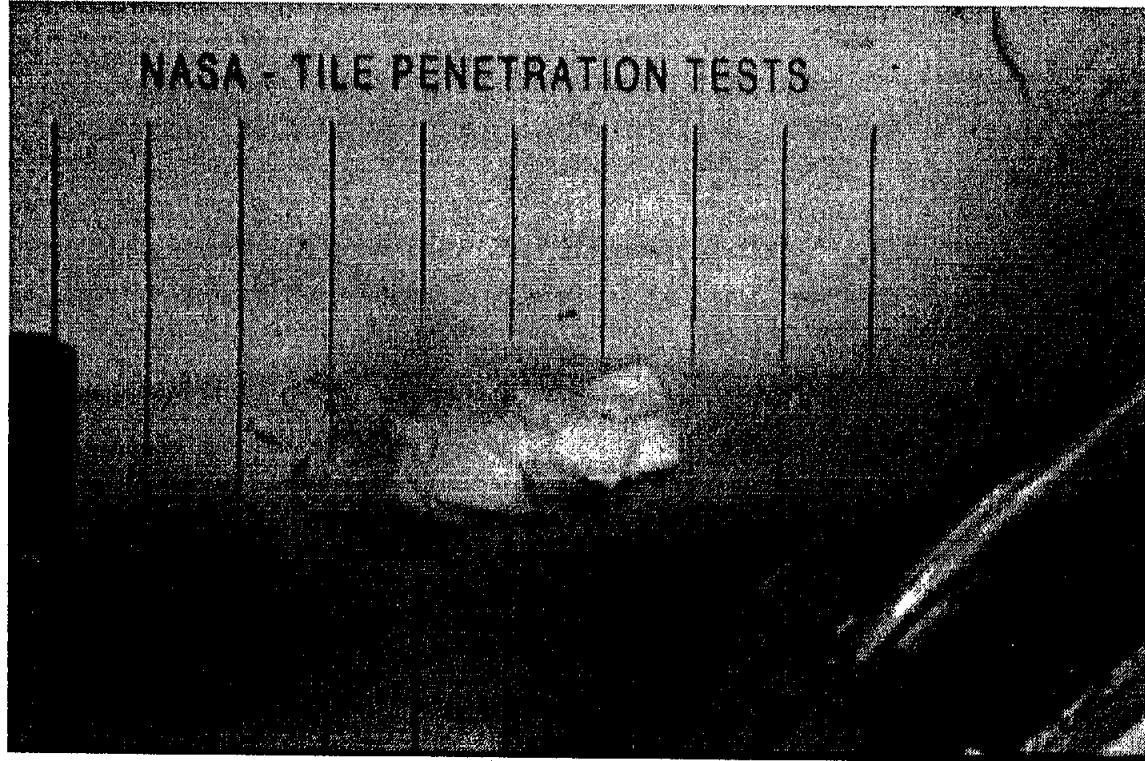
Test No. 60 - Imacon Frame No. 1

NASA - TILE PENETRATION TESTS



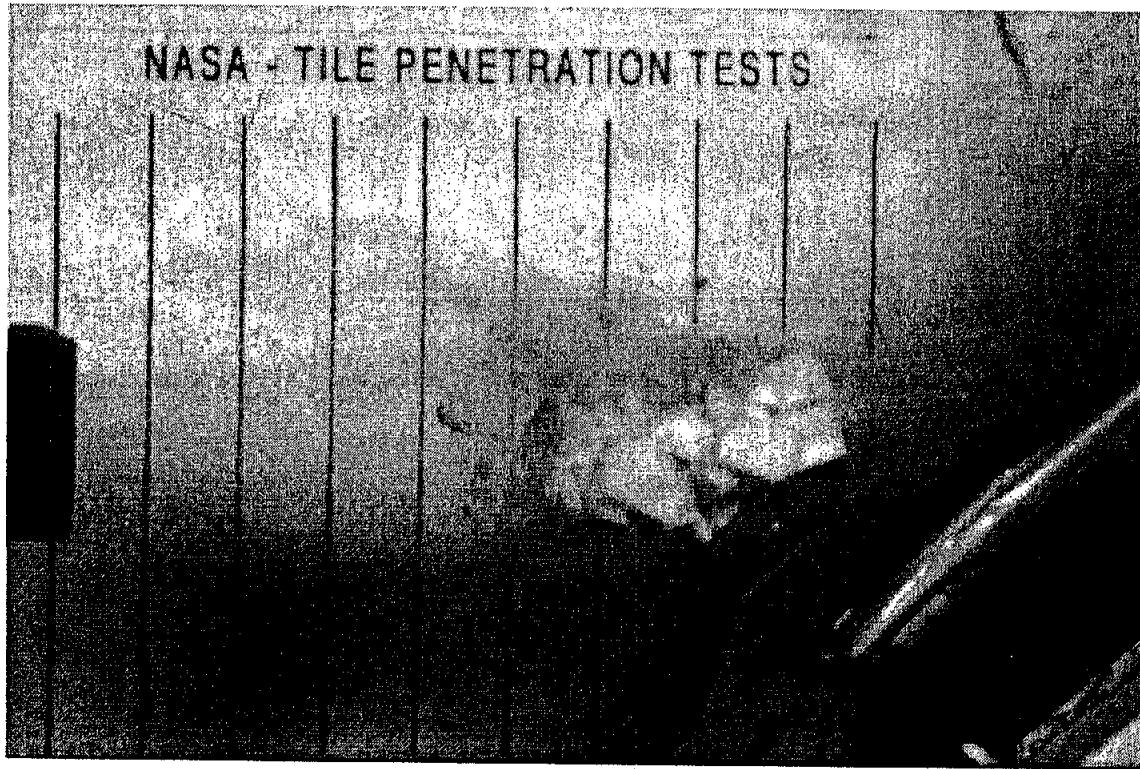
Test No. 60 - Imacon Frame No. 2

NASA - TILE PENETRATION TESTS

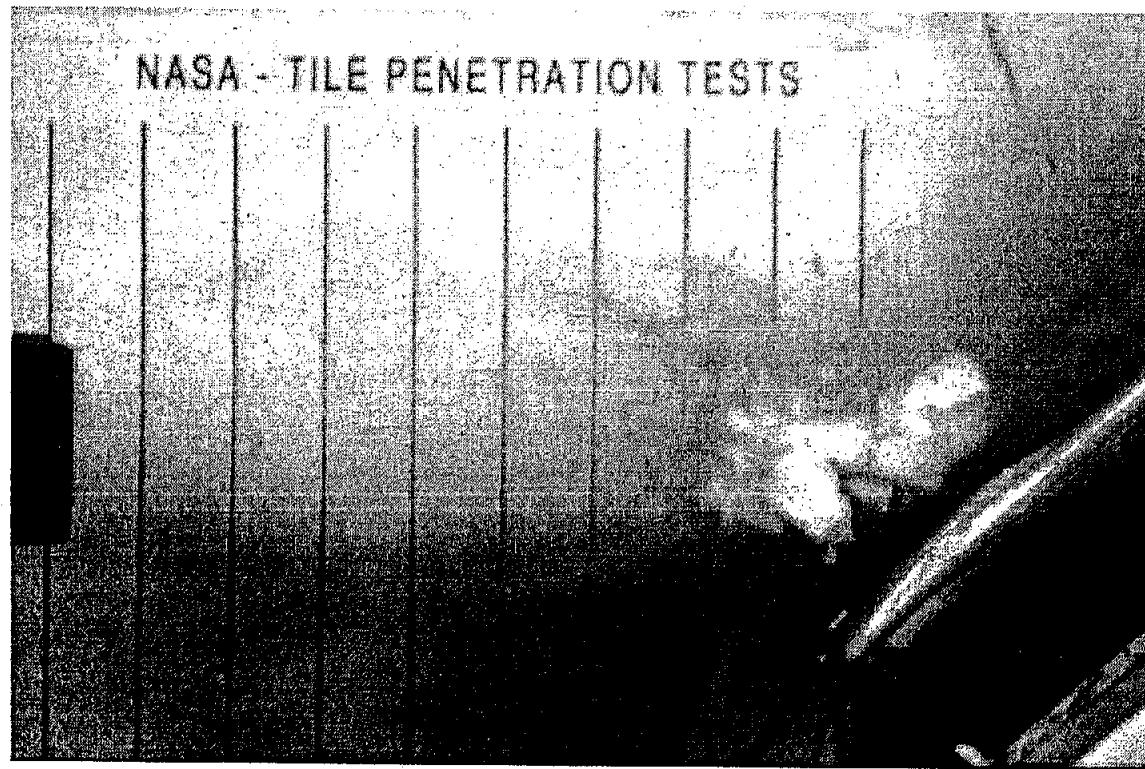


Test No. 60 - Imacon Frame No. 3

NASA - TILE PENETRATION TESTS

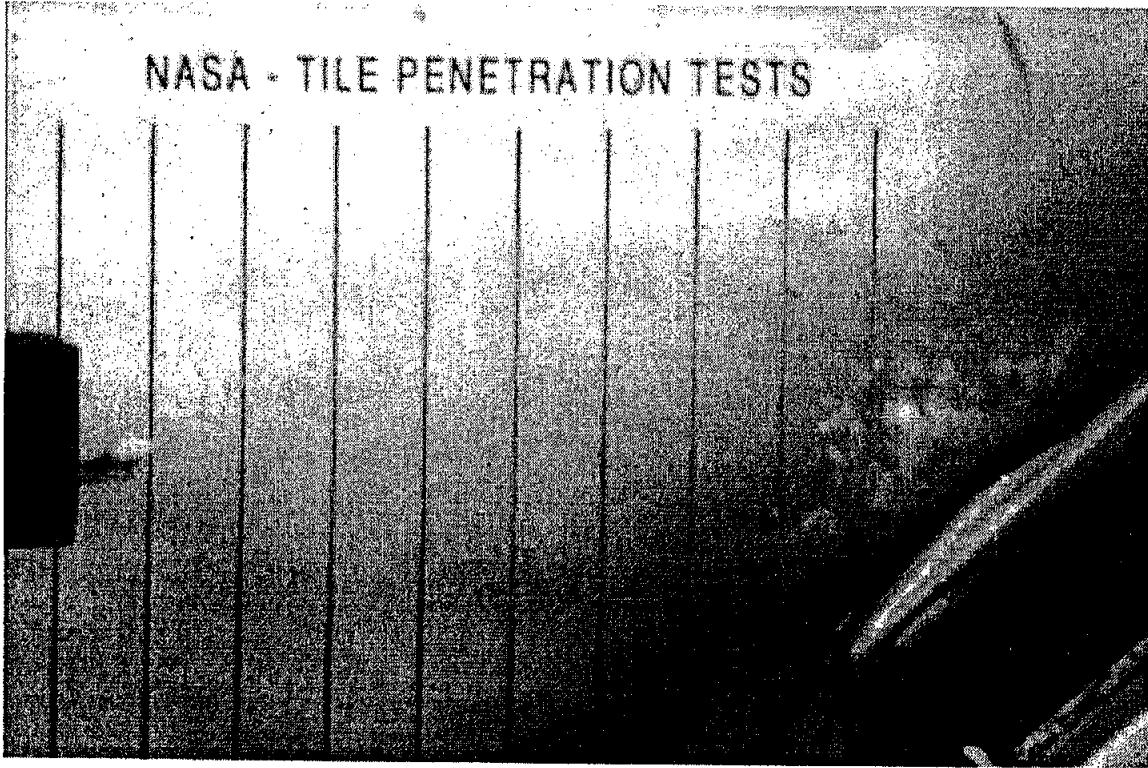


**Test No. 60 - Imacon Frame No. 4**



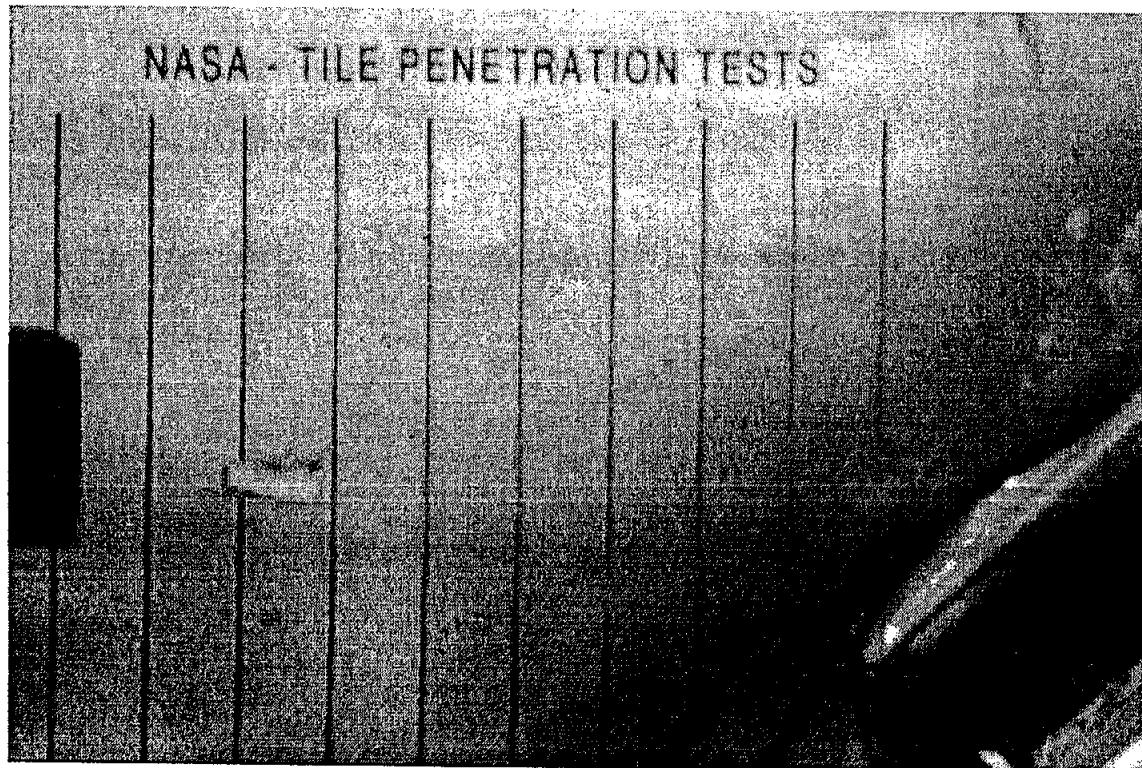
**Test No. 60 - Imacon Frame No. 5**

NASA - TILE PENETRATION TESTS



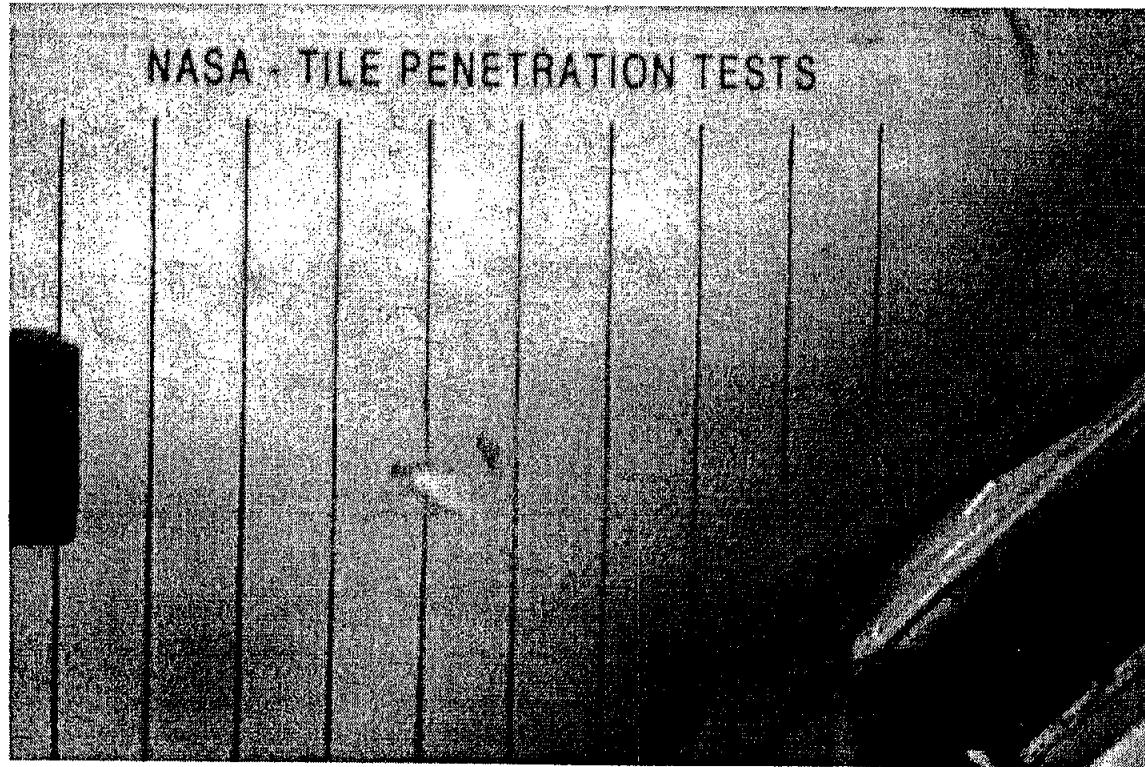
Test No. 60 - Imacon Frame No. 6

NASA - TILE PENETRATION TESTS

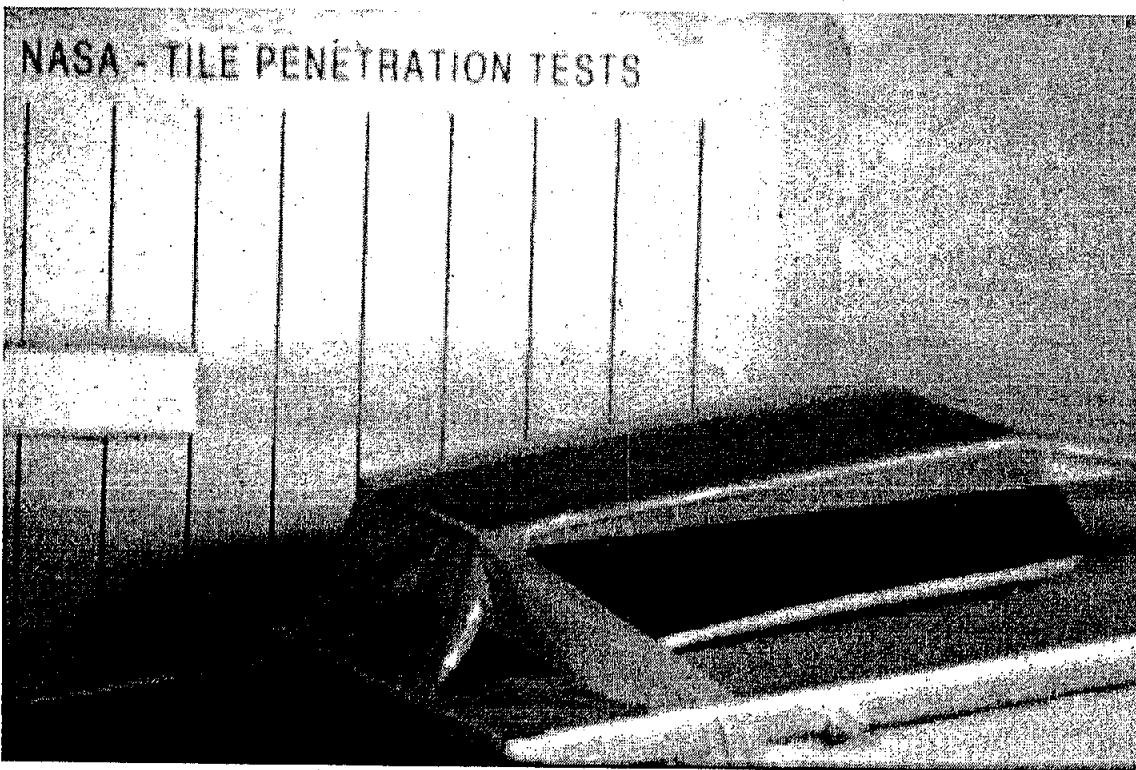


Test No. 60 - Imacon Frame No. 7

NASA - TILE PENETRATION TESTS

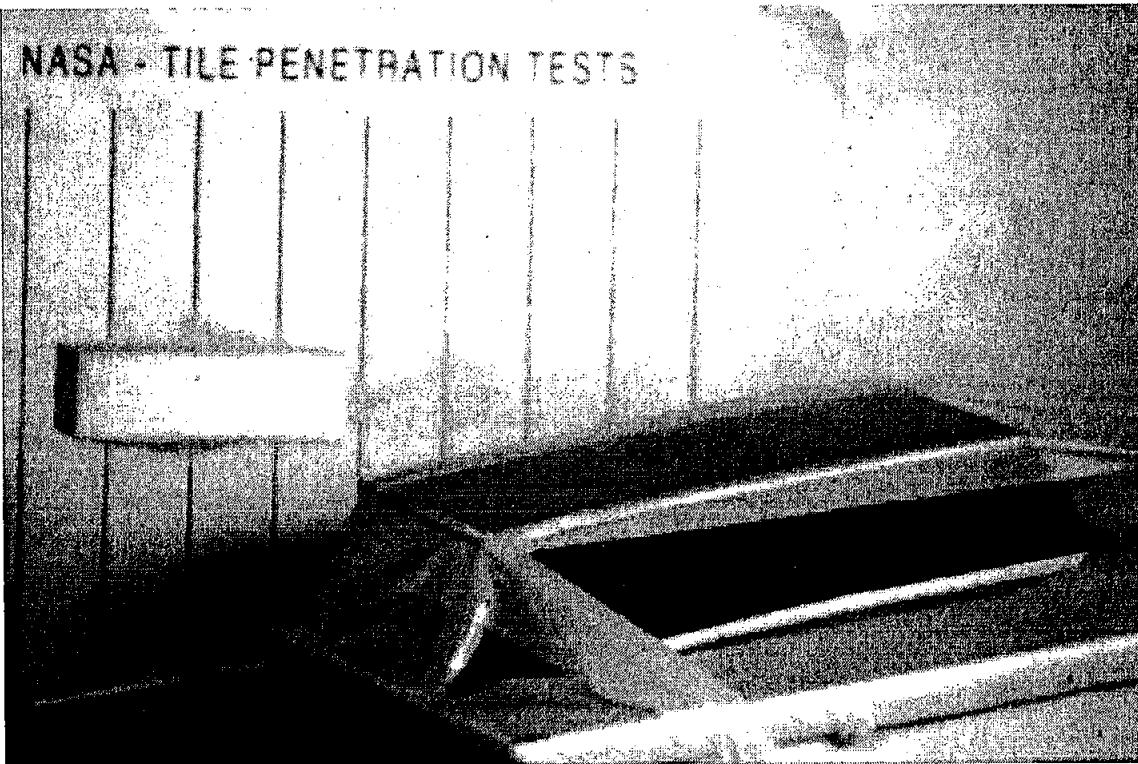


Test No. 60 - Imacon Frame No. 8

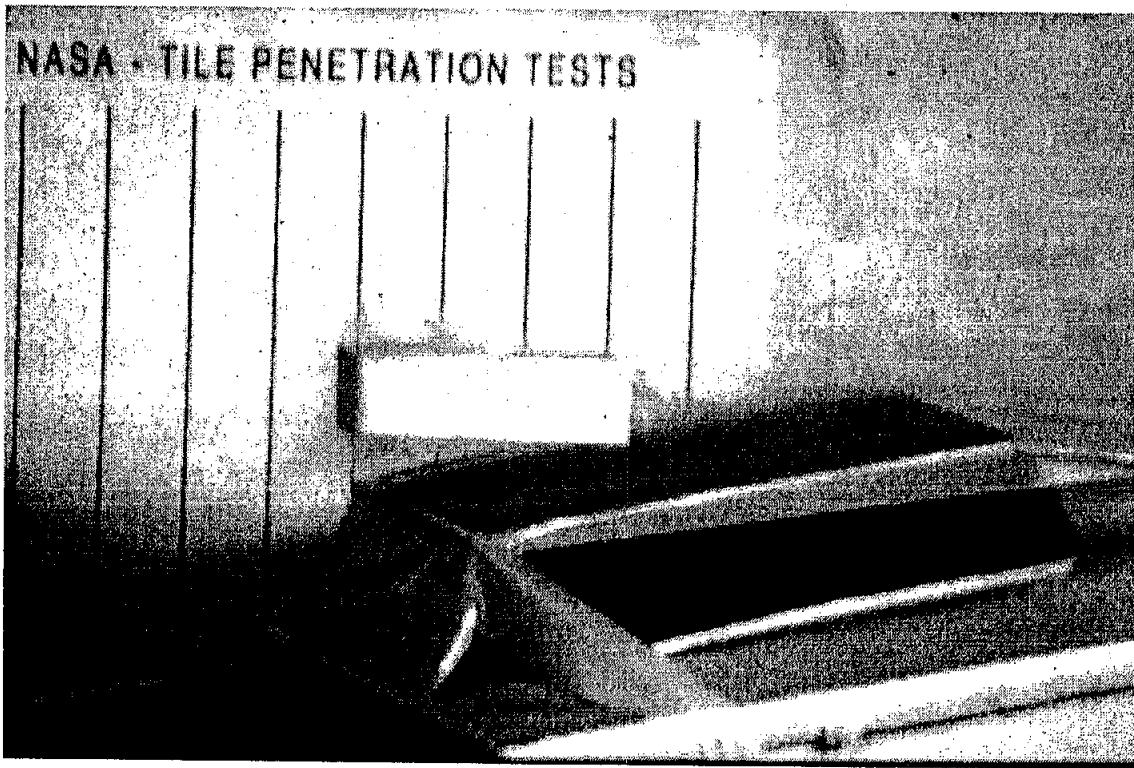


**Test No. 43 - Imacon Frame No. 1**

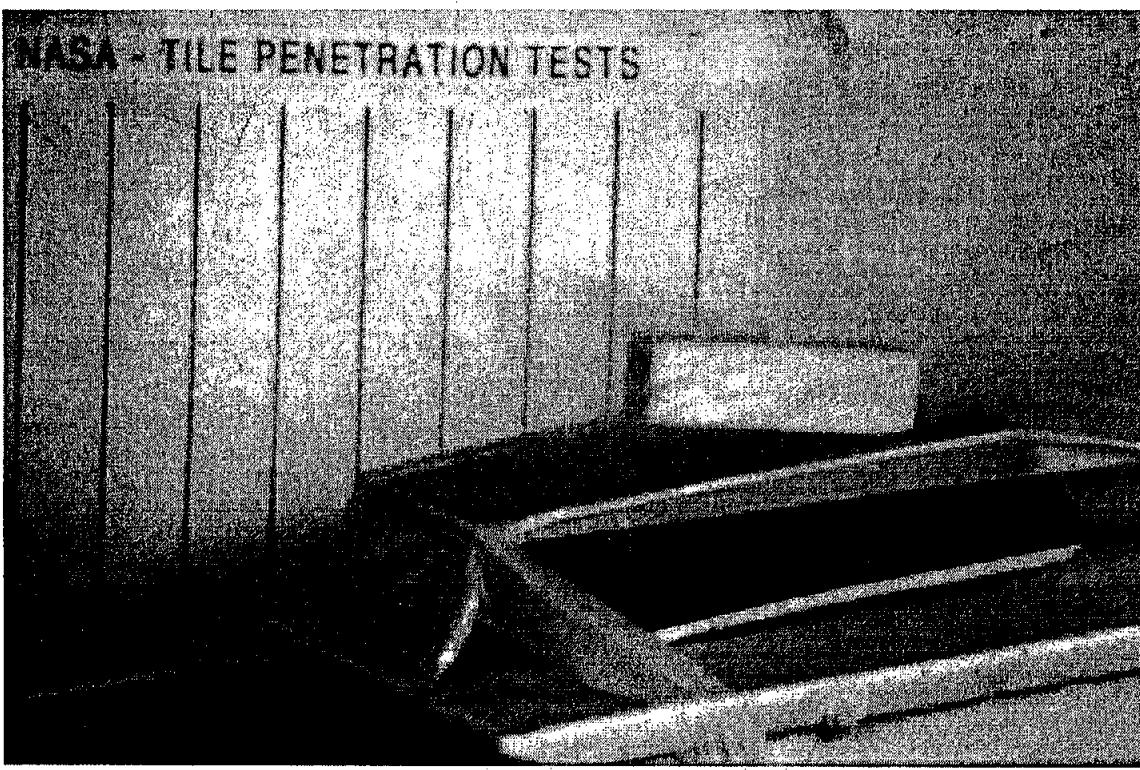
NASA - TILE PENETRATION TESTS



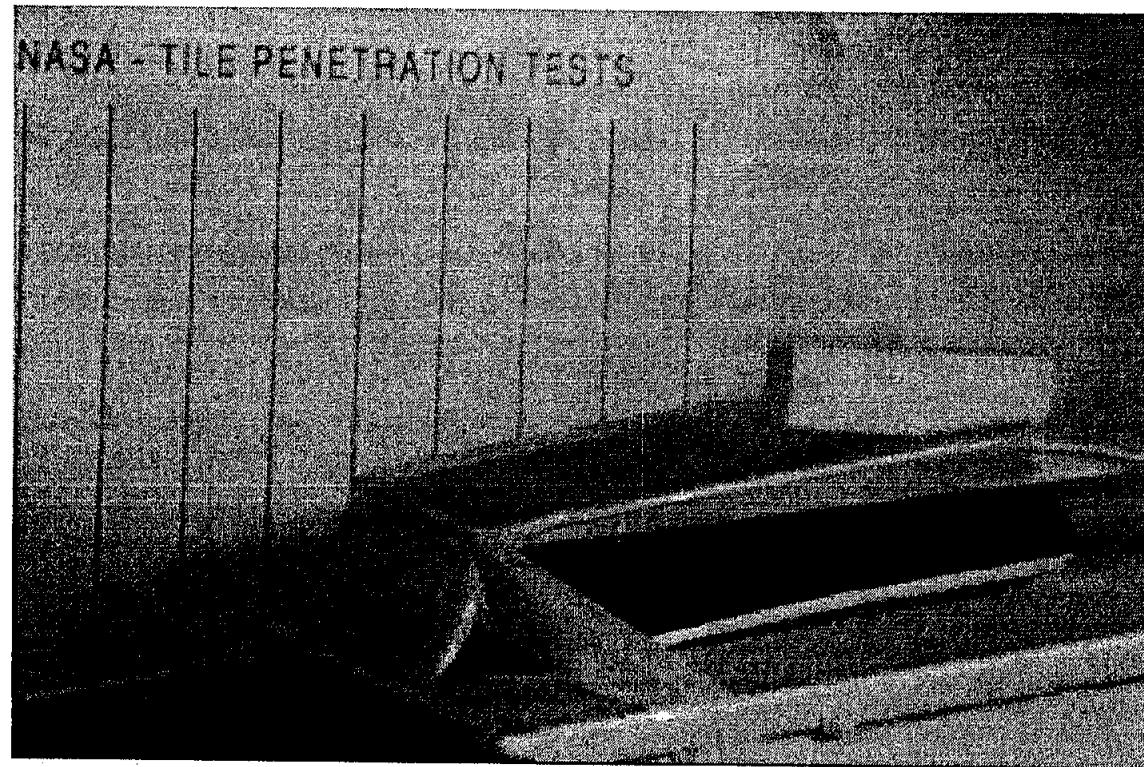
Test No. 43 - Imacon Frame No. 2



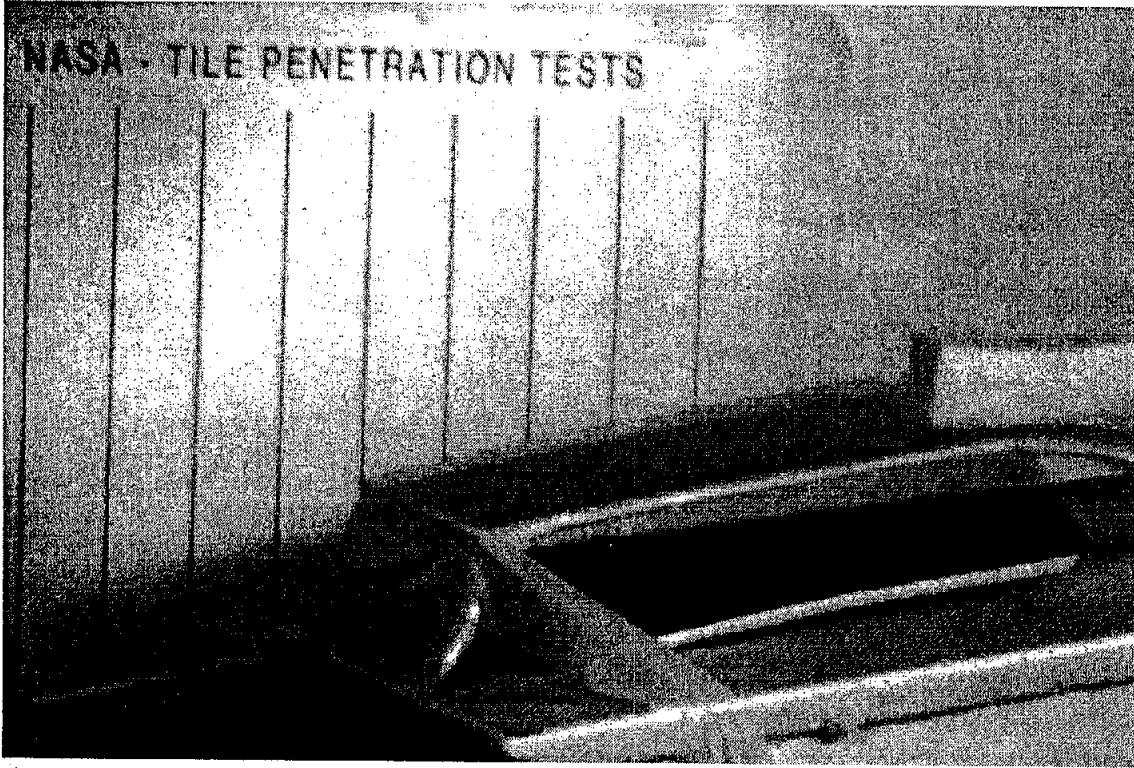
Test No. 43 - Imacon Frame No. 3



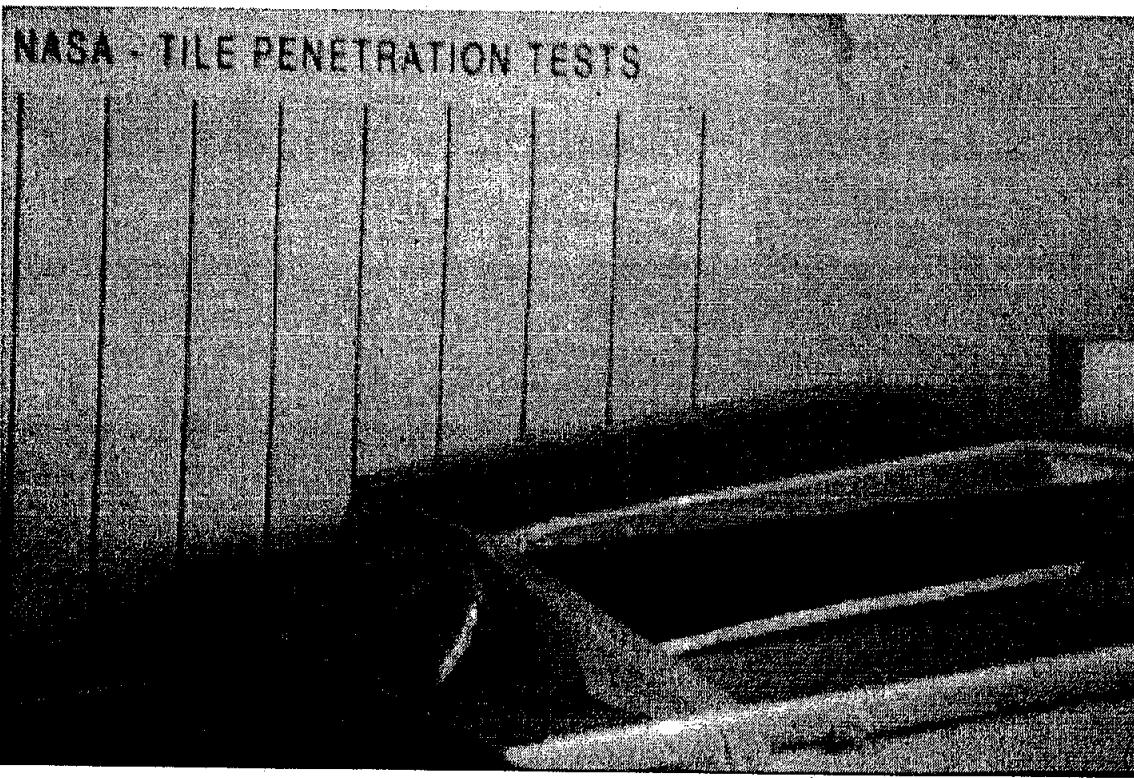
**Test No. 43 - Imacon Frame No. 4**



**Test No. 43 - Imacon Frame No. 5**

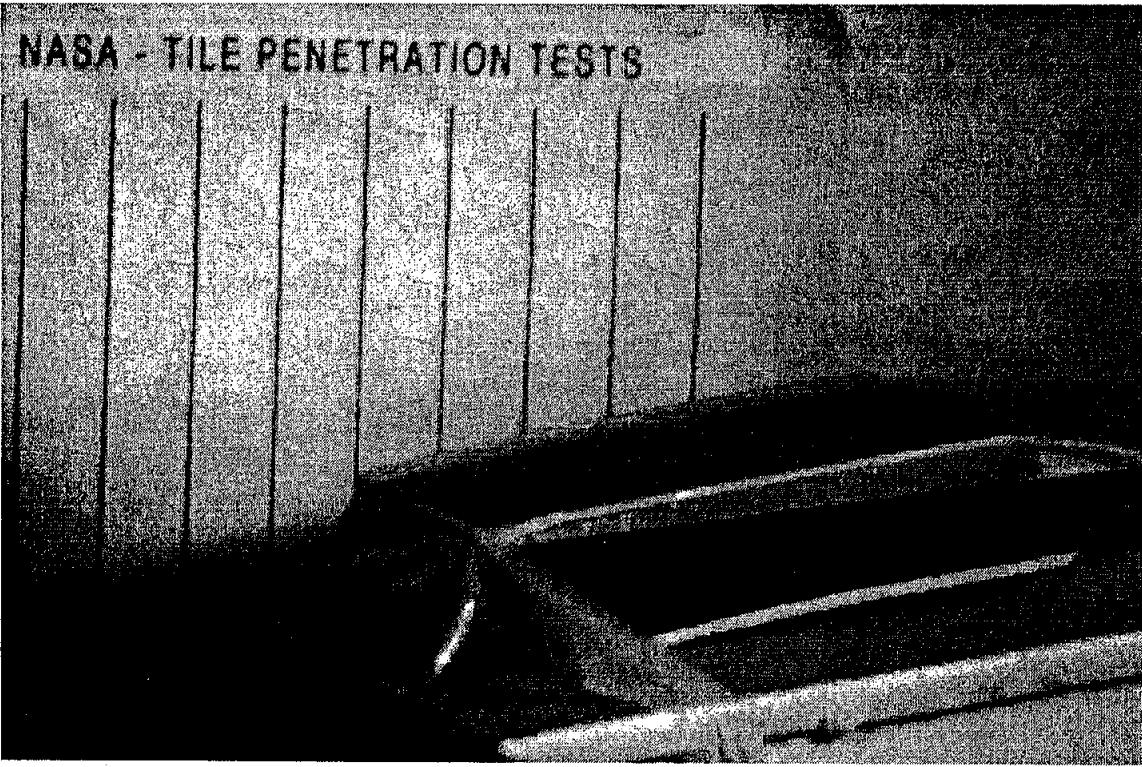


**Test No. 43 - Imacon Frame No. 6**

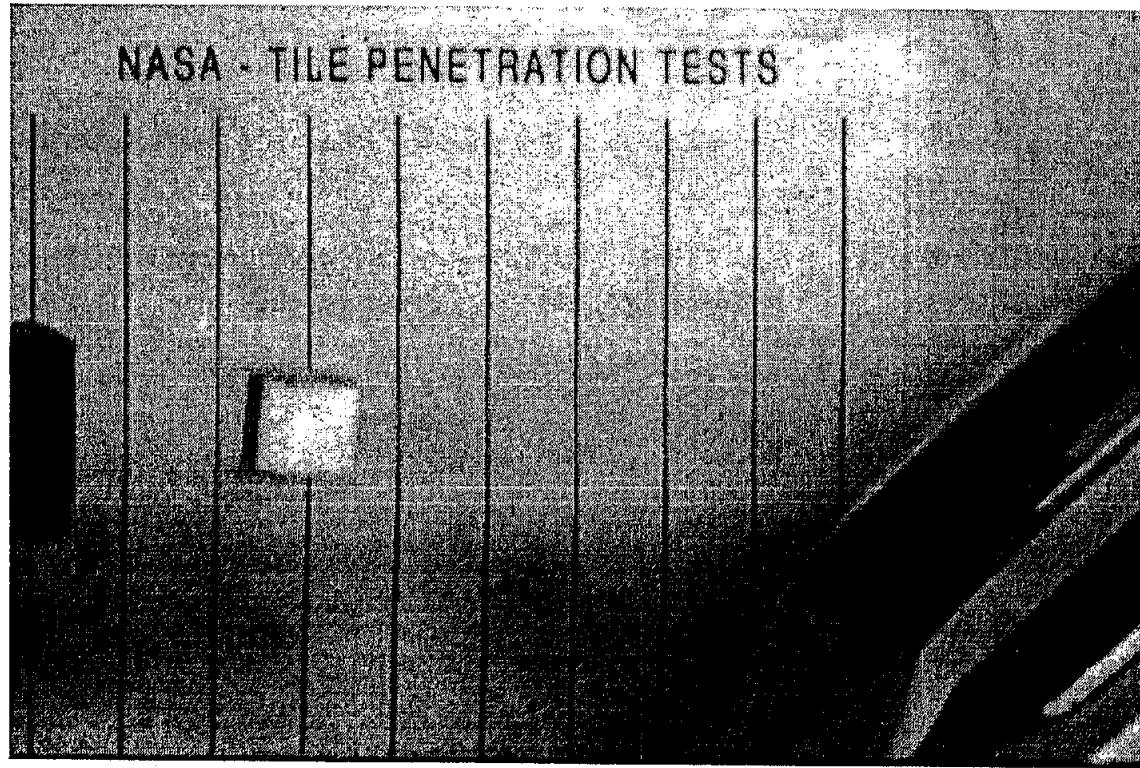


**Test No. 43 - Imacon Frame No. 7**

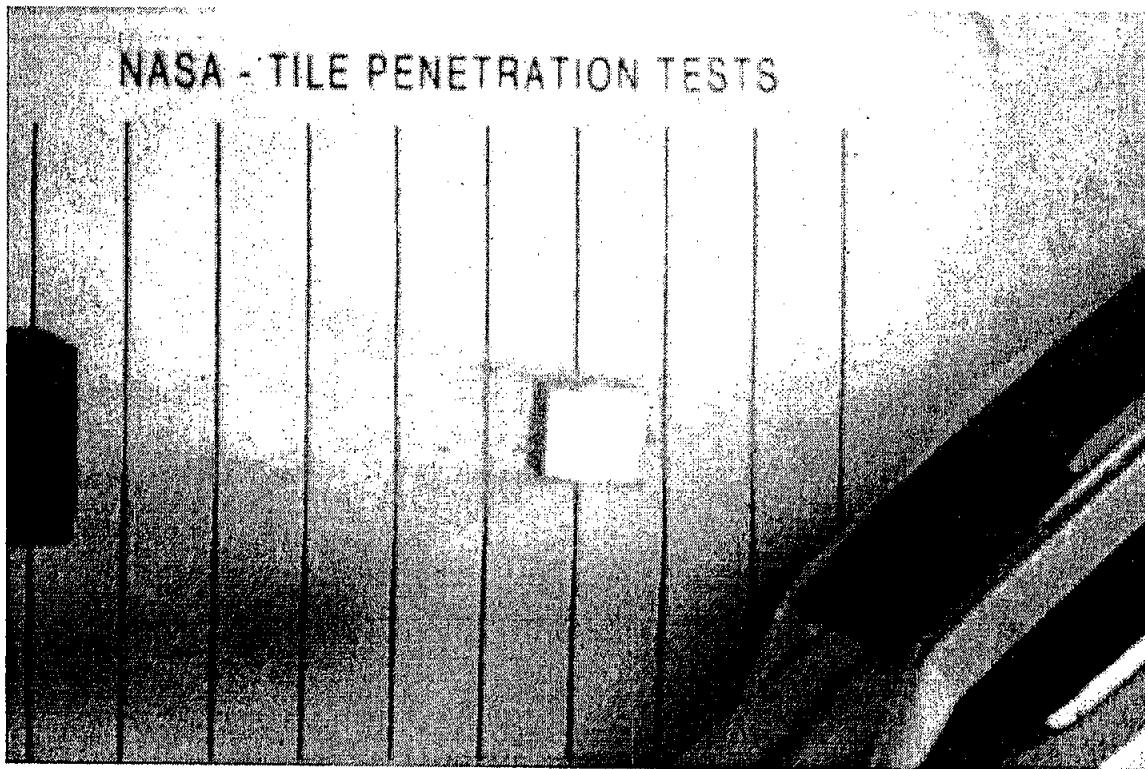
NASA - TILE PENETRATION TESTS



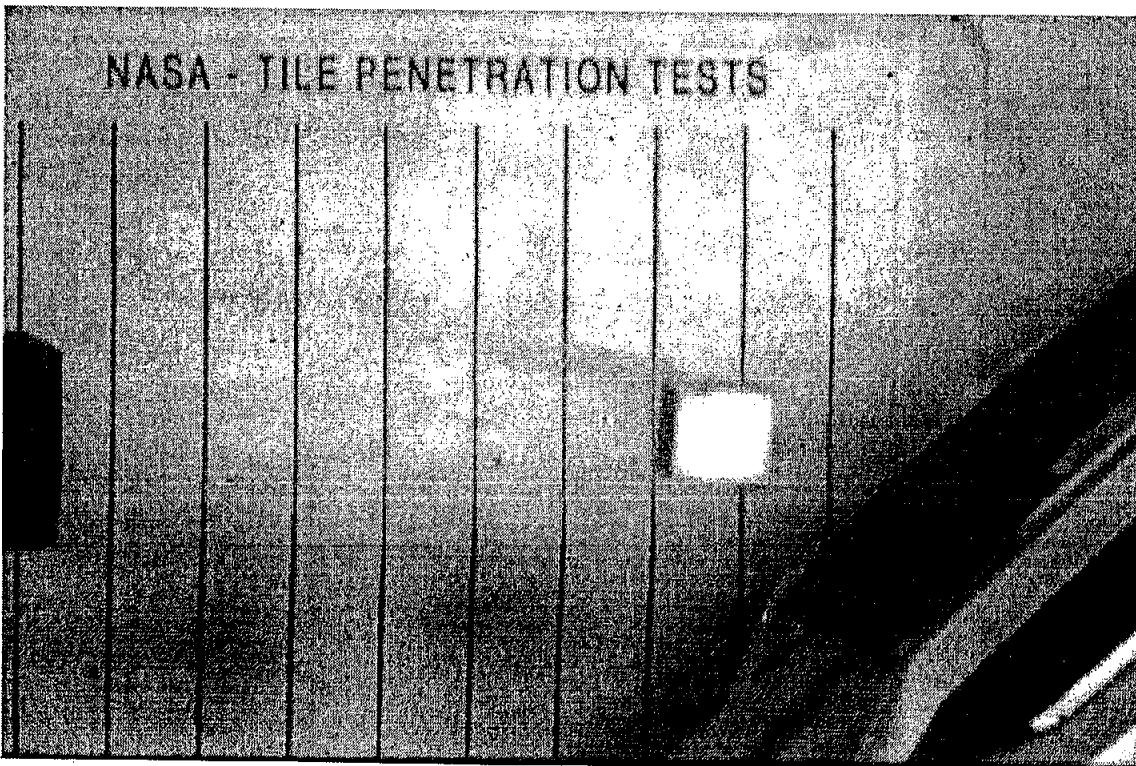
Test No. 43 - Imacon Frame No. 8



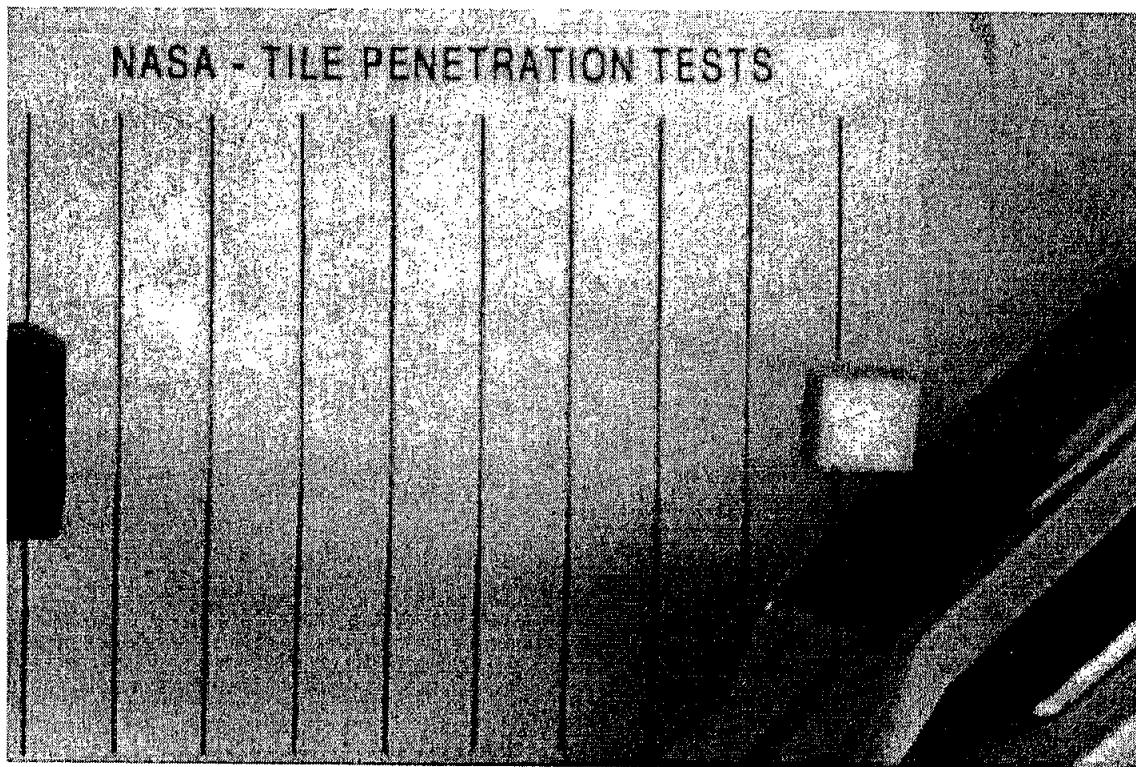
Test No. 39 - Imacon Frame No. 1



Test No. 39 - Imacon Frame No. 2

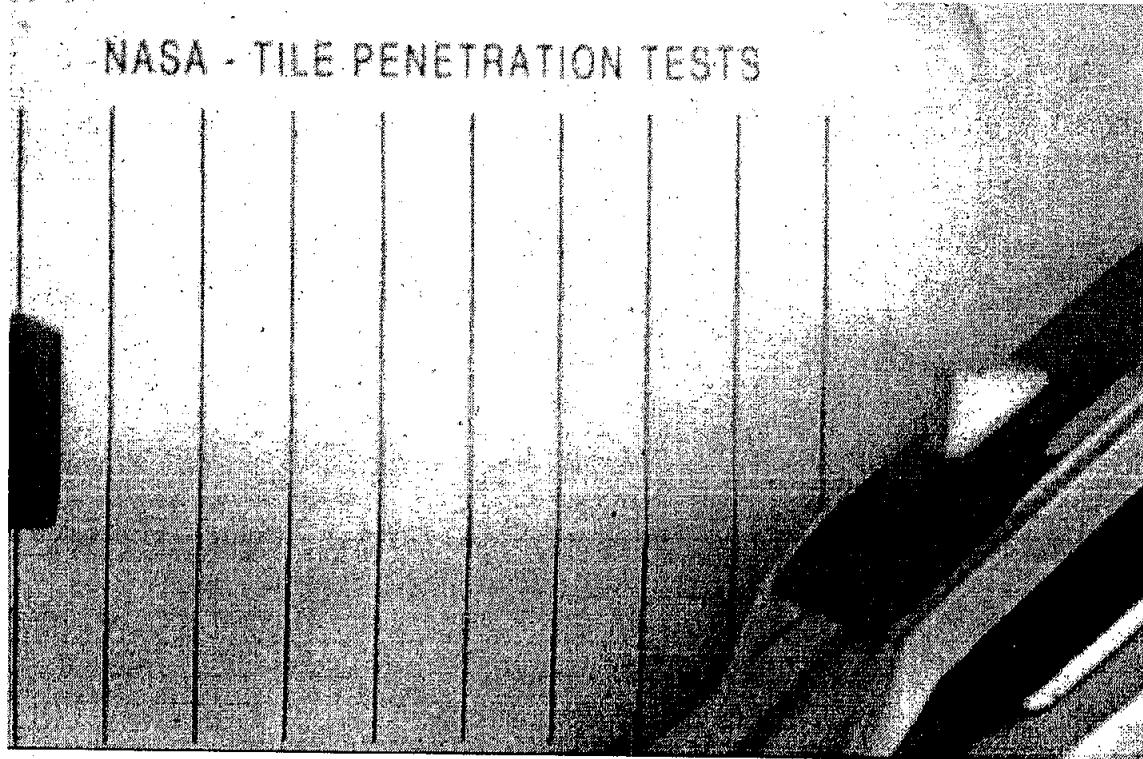


Test No. 39 - Imacon Frame No. 3



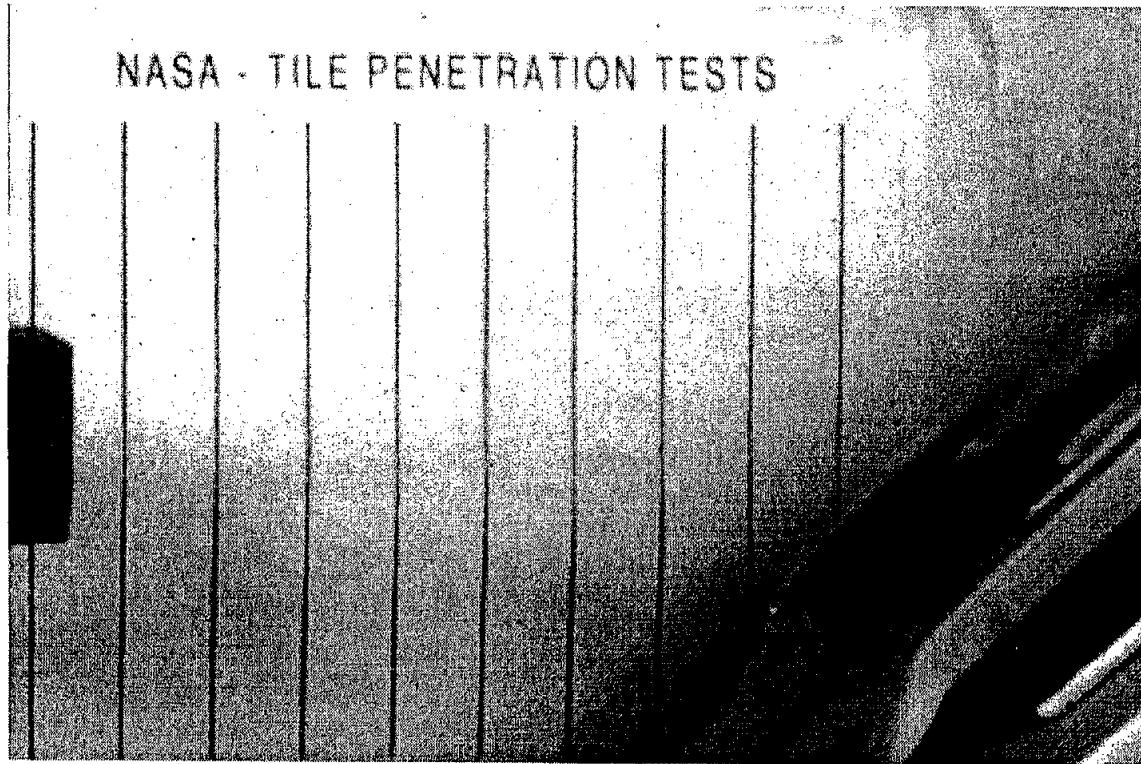
**Test No. 39 - Imacon Frame No. 4**

NASA - TILE PENETRATION TESTS



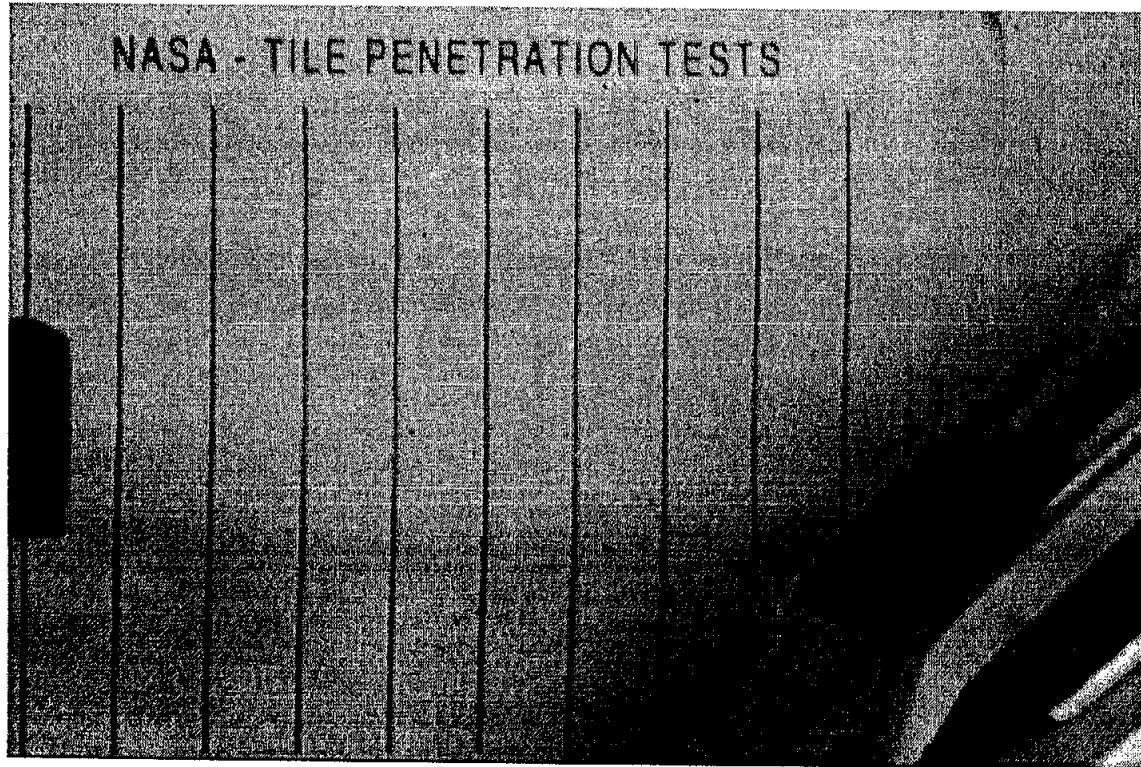
Test No. 39 - Imacon Frame No. 5

NASA - TILE PENETRATION TESTS



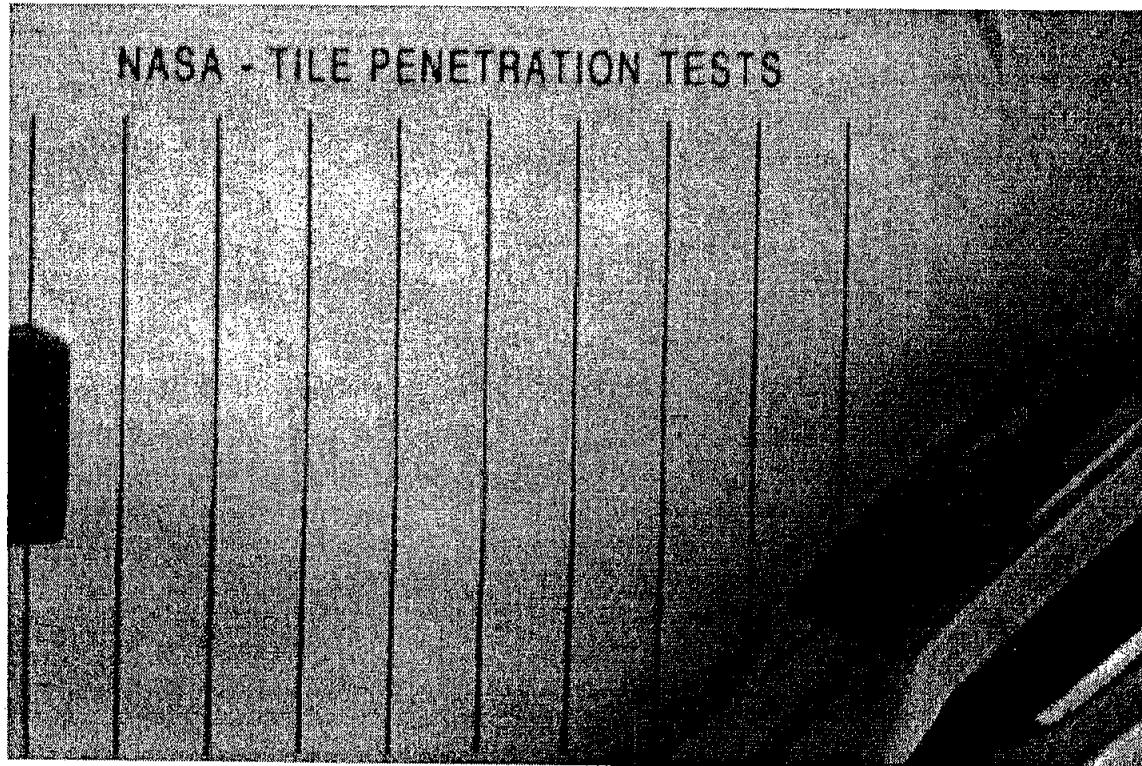
Test No. 39 - Imacon Frame No. 6

NASA - TILE PENETRATION TESTS

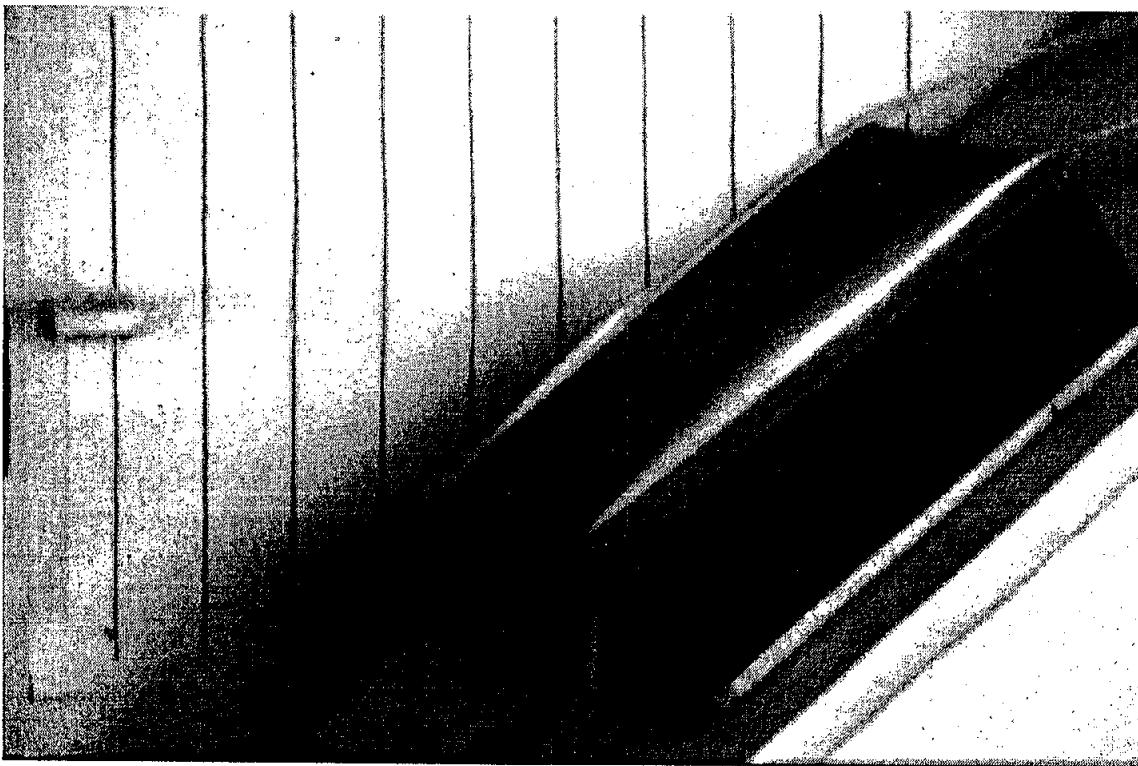


Test No. 39 - Imacon Frame No. 7

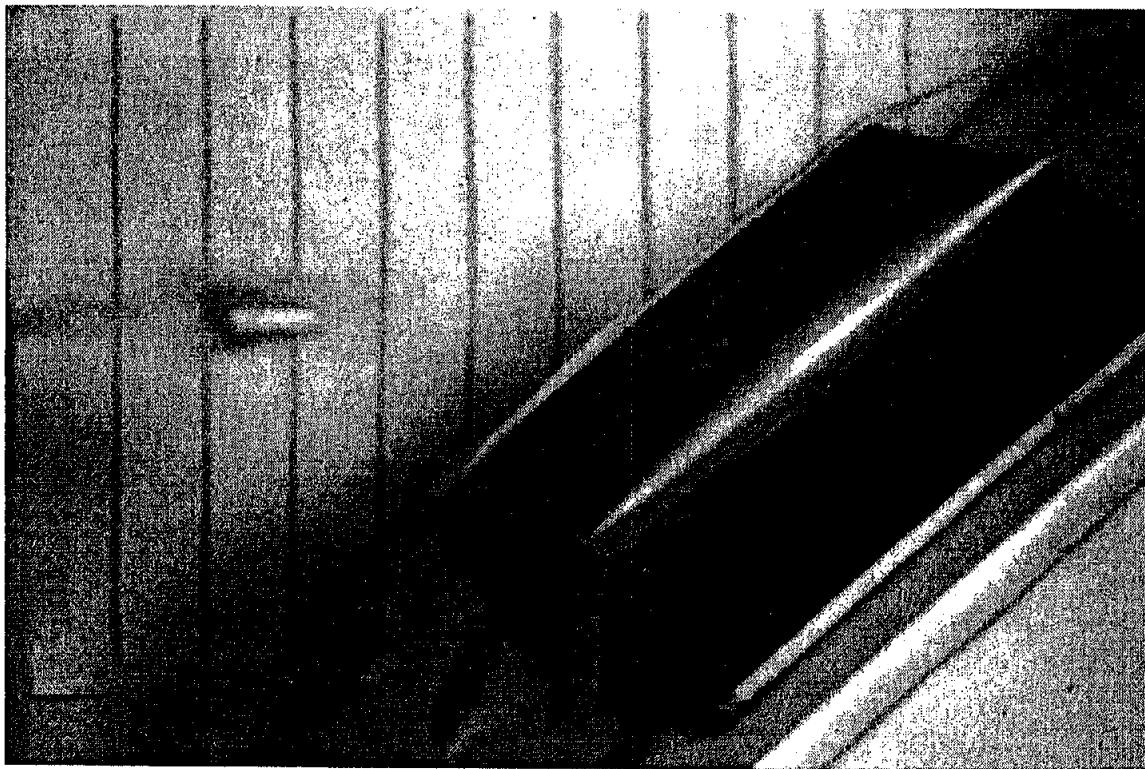
NASA - TILE PENETRATION TESTS



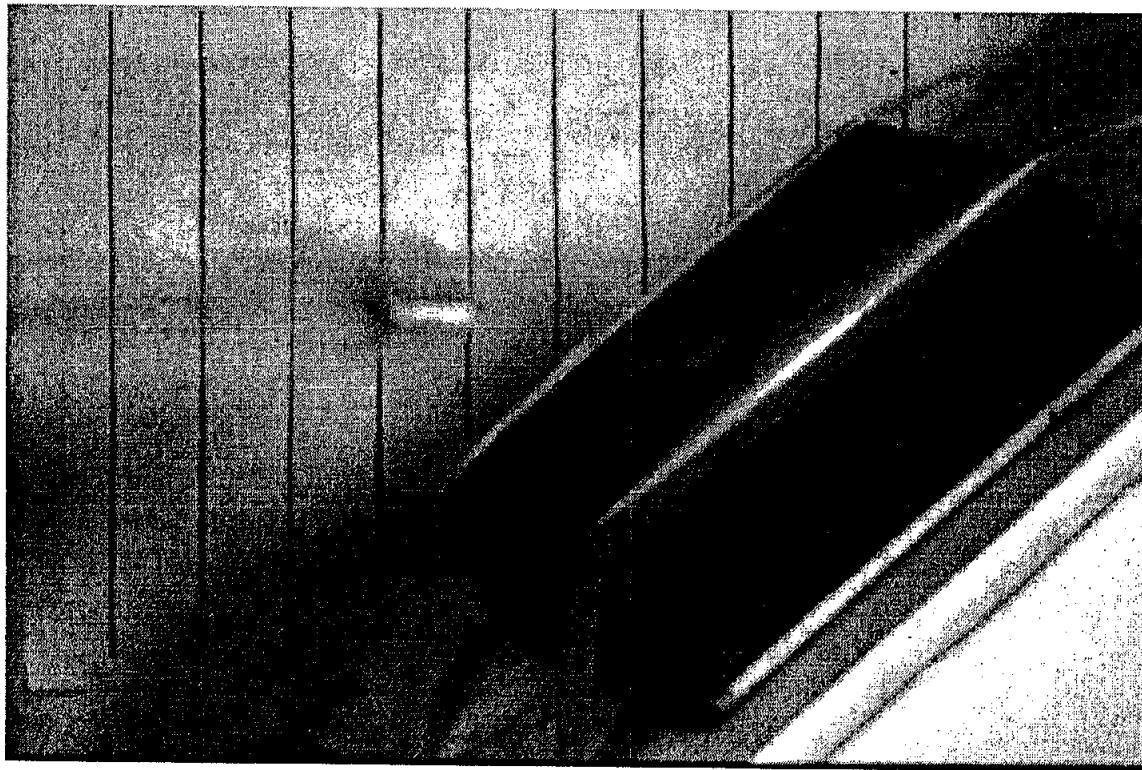
Test No. 39 - Imacon Frame No. 8



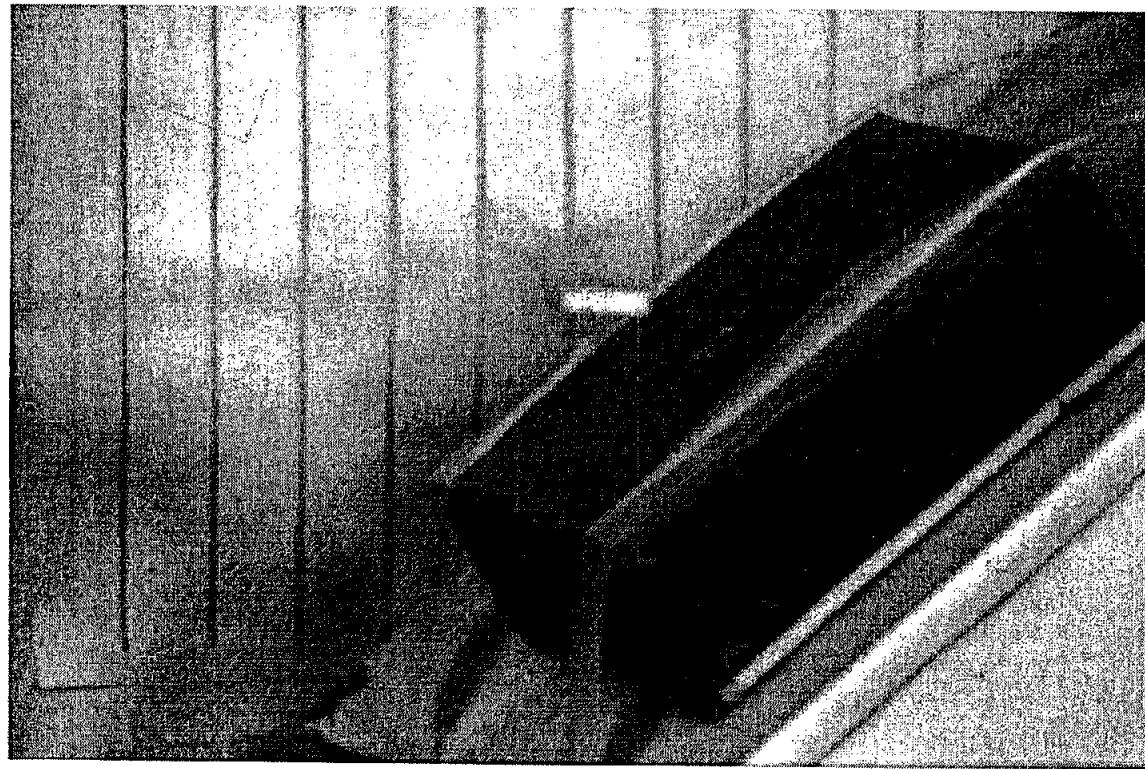
**Test No. 20(F) - Imacon Frame No. 1**



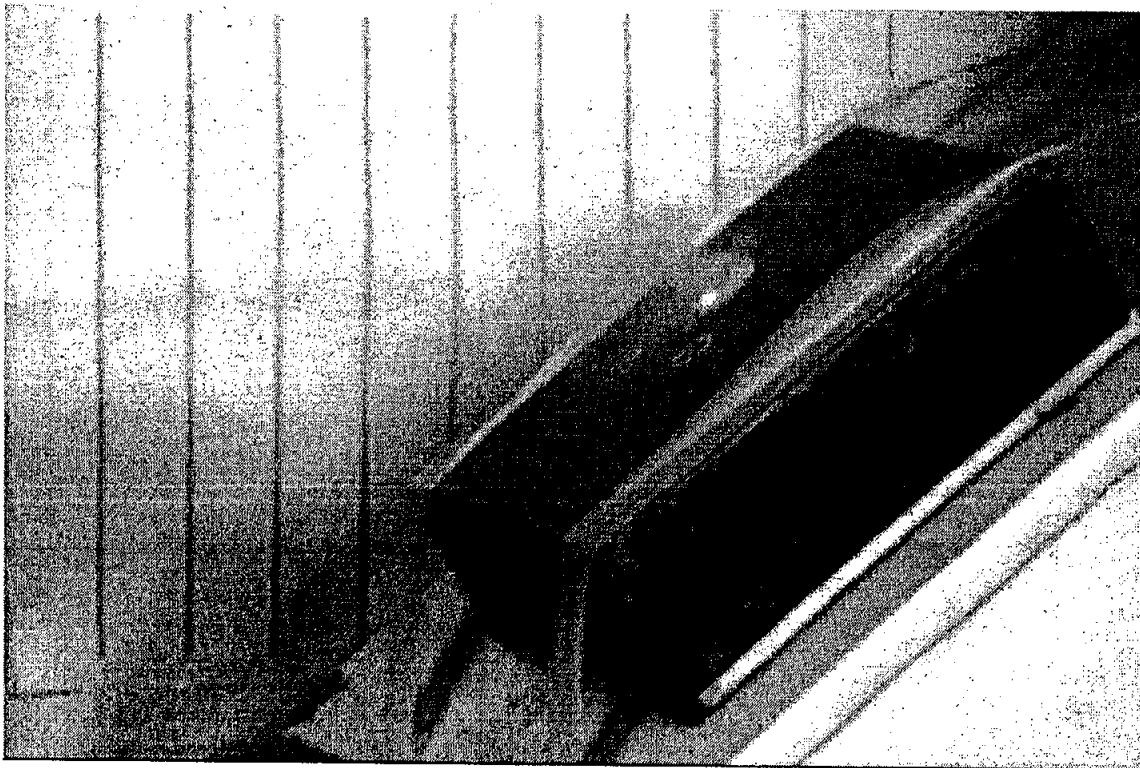
**Test No. 20(F) - Imacon Frame No. 2**



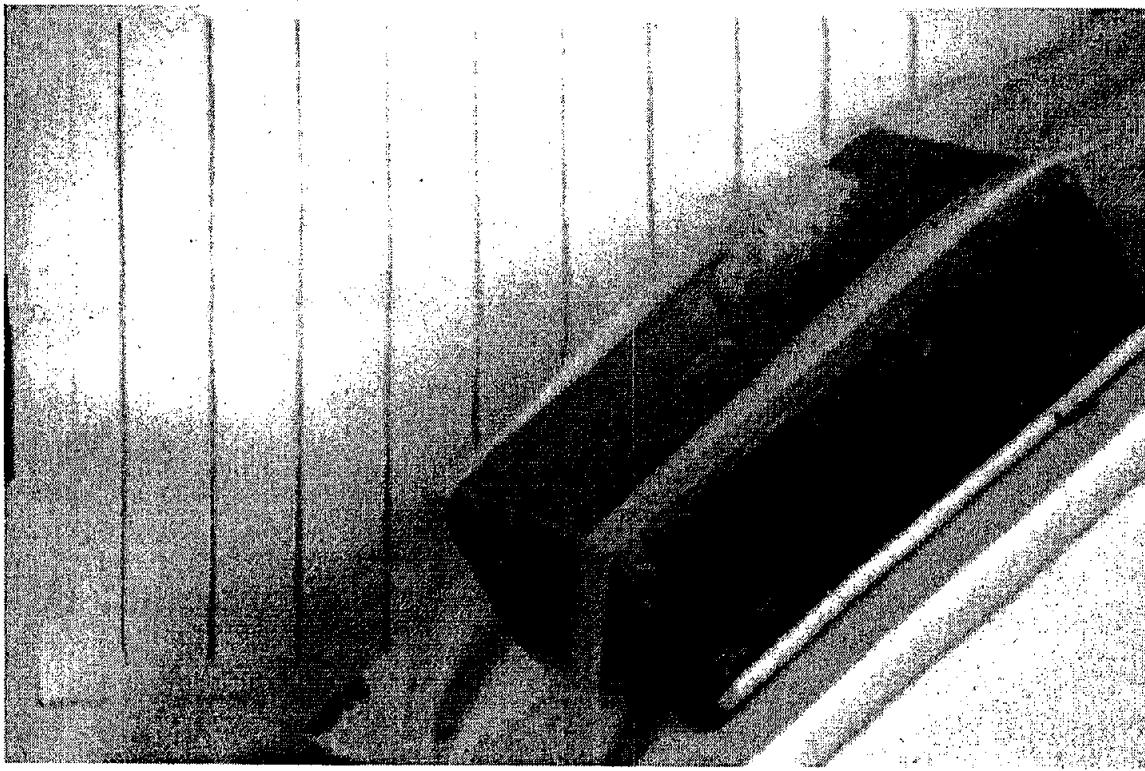
**Test No. 20(F) - Imacon Frame No. 3**



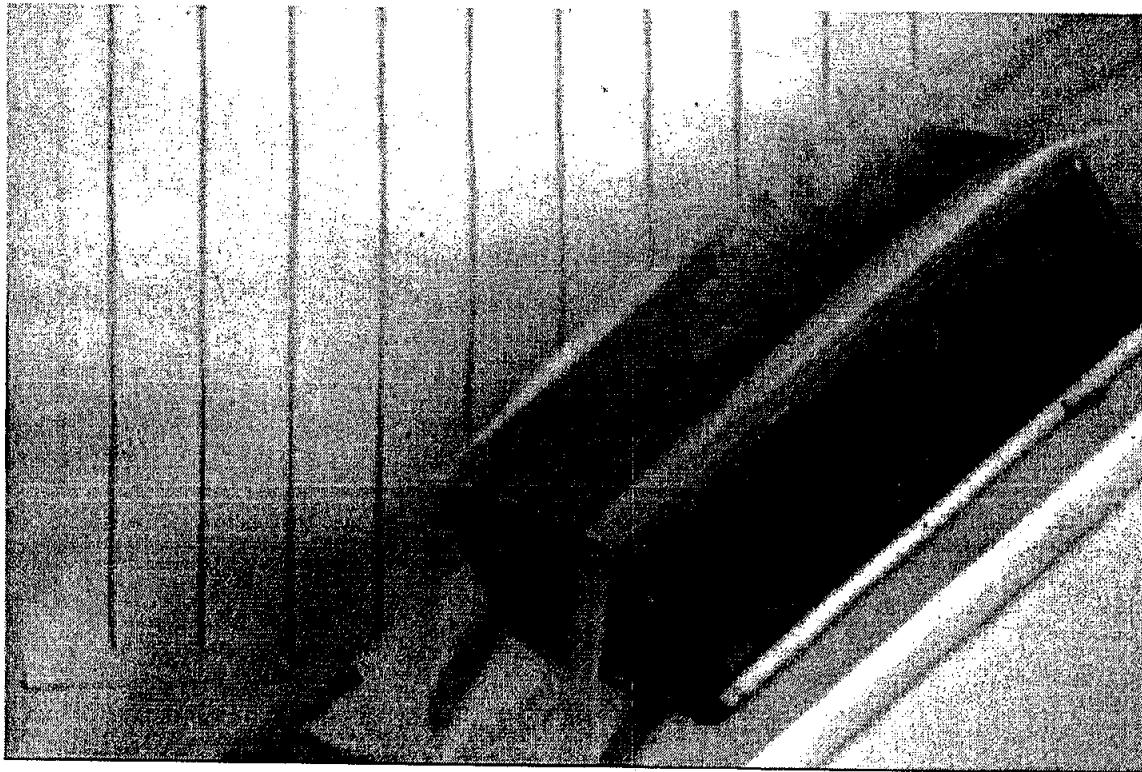
**Test No. 20(F) - Imacon Frame No. 4**



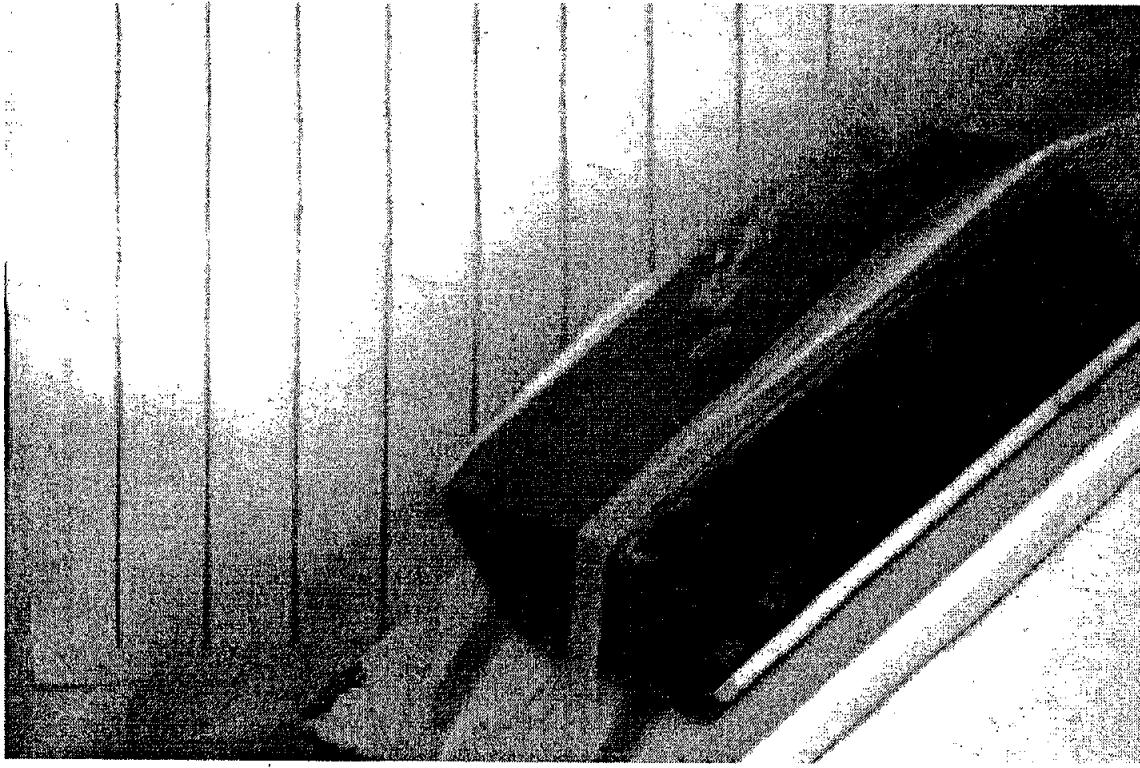
**Test No. 20(F) - Imacon Frame No. 5**



**Test No. 20(F) - Imacon Frame No. 6**



**Test No. 20(F) - Imacon Frame No. 7**



**Test No. 20(F) - Imacon Frame No. 8**